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Editorial

Original contributions from eminent scientists, technologists, researchers and science centre professionals have enriched this issue of Propagation to a great extent. We hope that in course of time the journal will be a trend setter in the chosen field of science communication.

The Origins and Evolution of Ayurveda, the age old Indian holistic knowledge of medicine for healthy and long life, is the topic of the first article of this issue of Propagation. The next article draws our attention to an important issue of 'Global Warming on Himalayan Ecosystem with special reference to Glacial lake Outburst Floods'. The principal aim of the article 'Open Innovation: A New Paradigm in Science and Technology' is to locate the sociological imperatives which is forcing S&T today to adapt this new mode of innovation. The focus of the next article is on Science Communication through Print Media. Notwithstanding the rapid diversification of communication media, especially with the growth of ICT-based systems, the print media continue to remain a powerful contender in the field of science communication.

The author of the article 'Towards the Next Generation Multimedia Presentation' proposes a new framework of structuring multimedia presentations to address many of today's requirements, like need for frequent content updation, customizimg the presentation according to users' requirements, transmitting the presentation over low bandwidth networks and supporting distributed media components. A permanent exhibition "Our Science and Technology Heritage" was created by National Council of Science Museums at the National Science Centre, Delhi for portraying authentic information on the S&T Heritage of India. For dissemination of this information an article titled 'Presenting Indian Science and Technology Heritage in Science Centres' in two parts has already been published in the earlier two issues of this journal. The third and final part of the article is included in this issue of Propagation.

Increasing population and mounting carelessness of the precious resource has placed tremendous stress on the limited supply of water around the world. 'Water - The Elixir of Life' describes a new interactive gallery at the National Science Centre, Delhi which sensitizes the visitors on the multiple issues associated with this problem and aims to create an awareness on the subject. The article 'The Metrology behind Harappan Town Planning' proposes the existence of a Harappan linear unit of 1.9 m at sites such as Dholavira, where the city's major dimensions take felicitous expressions in terms of this unit. It then relates it to a "Harappan angula" of 1.76 cm, with a factor of 108 between the two, as indicated in classical literature, which suggests continuity between India's two urbanizations. There are two critical reviews in this issue of Propagation on social inclusion through extensive activities of science museums and science centres in India.

We hope that the third issue will satisfy the reader. The previous issues did so. We welcome constructive suggestions for improvement of the journal.

Jayanta Sthanapati
Chief Editor

Propagation
A Journal of Science Communication
Volume 2, Number 1, January 2011

CONTENTS

Page

Editorial 1

Contents 2

Ayurveda : Origins and Evolution ..... *Rajesh Kochhar* 3

Global Warming on Himalayan Ecosystem with special reference to Glacial Lake Outburst Floods ..... *Tarak Mohan Das* 7

Open Innovation: A New Paradigm in Science and Technology ..... *Tushar Chakraborty* 12

Science Communication through Print Media ..... *Biman Basu* 16

Towards the Next Generation Multimedia Presentation ..... *Ranjan Parekh* 23

Presenting Indian Science and Technology Heritage in Science Centres (Part III) ..... *Shivaprasad M Khened* 38

Water –The Elixir of Life : A New Gallery at National Science Centre, New Delhi ..... *N Ramdas Iyer* 49

Social Inclusion through Science Centre Activities in India ..... *Arijit Dutta Choudhury* 56

The Metrology behind Harappan Town-Planning ..... *Michel Danino* 59

Social inclusiveness of Indian Science Centres & Museums – A Snapshot through Case Studies (Part I) ..... *Shubhabrata Chaudhuri* 71

Propagation
A Journal of Science Communication

Ayurveda: Origins and Evolution

Rajesh Kochhar

Abstract

Quest for good health and long life is probably as old as human existence itself. Human beings have always believed that they are entitled to die of old age rather than disease. Towards this goal they have striven at spiritual as well as material level. Evil spirits were sought to be driven off through charms, incantation and magic, with appeal made to the Creator to be the Saviour and Healer also. At the same time, recourse was taken to medication also. The premise that disease has a cause and efforts need to be made to remove it eventually led to the establishment of a health care system.

The beginnings of medical science in India are contained in the Vedic literature itself. The Rgveda describes the Asvins, Varuna and Rudra as bhisaj, physicians (Macdonell & Keith 1912 II:104). By bhesaj is meant "remedy", incorporating charms, magic, incantation, etc. This concept goes back to the era of Indo-Iranian commonality because equivalent terms occur in the Avestan literature as well: manthra baesaza [mantra bhesaj] and haoma baesazya [soma bhesajya] (Bloomfield 1899:58). At the same time, the Vedic literature is familiar with osadhi, that is plants with medicinal properties. As time progressed, the domain of osadhi expanded at the expense of bhesaj, and osadhi itself transcended plants. The discipline of Ayurveda was born as an affiliate of the Atharvaveda.

Made up of two Sanskrit words Ayuh (life) and Veda (knowledge), Ayurveda can be defined as an ancient Indian health care system, comprising both practice and theory, and devoted to a systematized quest for a long, healthy, vigorous and happy life. It comprises two distinct traditions: botanical and the metallurgical ("rasa"). The botanical is the older. The metallurgical with emphasis on mercury constitutes the Siddha system.

That these two streams have always been perceived as distinct can be seen from the fact that they are linked to different divinities: the botanical to the Asvins and Indra, and the metallurgical to Rudra/Siva (Ramachandra Rao 1985 I:62,80). There are eight divisions (anga) in Ayurveda: salya-tantra (surgery); salakya-tantra (diseases of head and neck); kaya-cikitsa (general medicine); bhuta-vidya (dealing with evil spirits, etc.); kaumara-bhrtya (paediatrics); agada-tantra (toxicology); rasayana-tantra; and vajikarana-tantra (dealing with aphrodisiacs, etc.).There is a vast

time. To be able to critically examine the issues pertaining to the origins and evolution of Ayurveda, we must first review the nature, content and limitations of the extant source material. Here, our emphasis will be on the botanical Ayurveda.

Source Material

The Vedic texts because of their sanctity were preserved in their original form. In the case of the Puranas and the epics, additions were made but not deletions. In contrast, scientific texts such as dealing in healthcare and astronomy generally underwent both deletion and addition. All the well known historical limitations of an oral tradition apply to Ayurveda also. Once an influential text appeared on the scene, contributing and lesser texts were forgotten. We learn about their existence from stray references in survived texts. As befit a field science, Ayurvedic classics were often redacted. We know only about the final or the latest recension. There is often confusion about names. It is not always possible to distinguish between persons of the same name but belonging to different eras. Many names remain shadowy, even though in their own time they would have been held in high esteem. Lesser authors are known to name their work after past celebrities so as to enhance their own work.

Chronology remains a serious problem made worse by non-rigorous research's passing off wild guesses as firm dates. It should always be borne in mind that in most cases, it is not possible to assign any date to an author or a text. In some cases, because of reference in texts or authors whose dates are independently known, useful time brackets can be assigned. Some times reference in dated literature from outside India gives a firm upper time limit. In short, it is not possible to construct a connected evolutionary history of Ayurveda.

Influential Texts

The two basic texts are Caraka-samhita, dealing with inner medicine or therapeutics (kaya-cikitsa), and Susruta-samhita, dedicated to surgery (salya). We discuss below these and other major Ayurvedic texts. They all essentially deal with botanical Ayurveda. Use of metals as medication along with the philosophy thereof constitutes a special tradition with its own

Caraka-samhita, Susruta-samhita and Vagbhata's Astanga-samgraha (5th century CE) have been termed Ayurveda's great triad (brihat-trayi) or ancient triad (vrddha-trayi), while three later texts, Madhava-nidana (7th/8th cent. CE), Sarngadhara-samhita (CE 1226) and Bhava-prakasa (16th cent. CE) have been called the three minor classics (laghu-trayi). In the following we review some of the influential Ayurvedic texts.

Caraka-samhita (?-? cent. CE). Atreya (son or descendent of Atri) is mentioned as a pioneer in medicine, and Dhanvantari in surgery. Assumed historical, both are of great but uncertain antiquity. Six pupils of Atreya are named: Agnivesa, Jatukarna, Bhela (also spelt Bheda), Harita, Ksirapani (or Ksarapani) and Parasara. All of them are believed to have composed their own texts based on their Guru's teachings, but only two have reached us. Bhela-samhita became a dead end, but it is historically valuable because it remains in its original form, unlike Agnivesa-tantra which led to greater things, but lost its own identity in the process. It was redacted by Caraka who, on the basis of his widely accepted association with Kanishka, can be placed in second century CE.

Even Caraka's work did not survive in its original form. With time, one third of it was lost and the remainder became inadequate. The missing parts were supplied and the whole redacted by Drdhabala, an inhabitant of Panchanadapura, in Kashmir, at the confluence of Indus and Jhelum, identified with present-day Panjor or Panchpanor (Ramachandra Rao 1985 I:56). Unfortunately, he cannot be dated with any certainty, except that he cannot be earlier than 4th century CE (See Navanitaka, below). It is his edition that we now know as Caraka-samhita.

Susruta-samhita (?-2 cent. CE). The surgery classic Susruta-samhita follows the same broad pattern as the Caraka-samhita , in the sense that it is also three-layered, but less details are known. The original text was codified by Susruta, of great but uncertain antiquity, on the basis of teachings of Dhanvantari. Devoted exclusively to surgery, it carried the name Sausruta-tantra. Later, a supplement was added with the tell tale title Uttar-tantra (later treatise), "which treated all subjects unnoticed" by the main text, no doubt to make the text self-contained. To give the whole text an appearance of thematic unity, the anonymous author of Uttar-tantra has also been dubbed Susruta (so that we have Susruta I and Susruta II).The whole text was redacted by Nagarjuna under the present-day title Susruta-samhita. From the extant text it is not possible to isolate the original Sausruta-tantra from the extant Susruta-samhita. It has been suggested [by Dalhan see below] that Nagarjuna himself is Susruta II. Nagarjuna is very likely the great Mahayana master and alchemist, who is associated with King Kanishka, and therefore placed in first/second century CE (Ramachandra Rao 1985 I:95). (There are later persons with the same name also). It has even been suggested that as with Caraka, Susruta (meaning famous) should be seen as a personification rather than a person. It thus appears that the final version of Susruta-samhita and the Caraka redaction of Caraka-samhita came into being at about the same time, of Kanishka.

Navanitaka, Bower manuscript (4th cent. CE). Authentic written information on where Indian medicine stood in fourth century CE comes from an unexpected source, a birch-bark manuscript from Kucha (also called Kuchar) in eastern Turkistan, on an ancient silk route. (Kucha is now the seat of a county in the Aksu prefecture, Xinjiang, China). Buddhism was introduced in Kucha in first century CE and by the third/fourth century CE it was a major Buddhist centre with numerous monasteries.

An important part of the Bower manuscript, so-called after its purchaser, Lieut. Hamilton Bower, is the digest called Navnitaka ("cream churned from curd"), which lists useful medical formulae culled from the then available sources. The digest is merely a copy, probably second hand, of a still older original. On paleographical grounds the manuscript has been dated about CE 350. Its contents must be somewhat earlier.

The listed formulae span a wide range: from hair wash and medicated oils to treatment of childless women. Interestingly, no source is cited in many cases: they mostly turn out to be standard treatises which presumably were expected to be well-known. A comparative study reveals that twenty-nine formulae are copied from the pre-Drdhabala portion of Caraka-samhita, suggesting that his own redaction was still in the future. Another fifteen come from Bhela-samhita. Three more formulae, dealing with atisara (diarrhea), are taken verbatim from Bhela-samhita. These three figure in Susruta-samhita's Uttar-tantra also, but in a different wording. We thus learn that Bhela was a source for Uttar-tantra. The older part of Susruta-samhita lends three formulae.

In case of some of the formulae, however, the authors are named. To the extent they can be identified, they are from the archives (Atreya and his four lesser pupils and others like Jivaka and Dhanvantari). As befits a scientific work, latest scholarship was considered more important than old masters.

Astanga-samgraha (6th cent. CE). The two classics, the Caraka and the Susruta, "are to an extent rambling and discursive" (Ramachandra Rao 1985 I:24). Their essential details have been "neatly collected" in the voluminous and comprehensive medical treatise Astanga-samgraha, prepared by Vagbhata, who is probably also the author of Astanga-hrdya-samhita, based on the former. (Like the astronomer Aryabhata, Vagbhata also has a single 't' in his name). Astanga-samgraha is the first medical text to incorporate astrological concepts. It is claimed that diseases which originate during different stellar (naksatra) conjunctions follow different courses. One wonders if Vagbhata's source on matters astrological was Varahamihira (6th cent. CE), because Varahamihira quotes a verse on rasayana from Astanga-samhita (Rama Rao 1992:216). This would suggest that Vagbhata was a contemporary of Varahamihira and therefore lived in the sixth century CE. This date would be broadly consistent with the well known fact that the Chinese Buddhist monk I-tsing who was in India during CE 673-685 seems to implicitly refer to Astanga-samgraha.

Madhava-nidana (7th/8th cent. CE). An outstanding work on diagnosis of diseases has been Rog-viniscaya (or Rug-viniscaya) authored by Madhava-kara, a native of Silahrada in Bengal and placed in the seventh/eighth century CE. The work is better known after him as Madhava-nidana. Madhava draws heavily on Caraka-samhita, Susruta-samhita, Astanga-hrdya-samhita and to a lesser degree on others including Astanga-samgraha. Some parts seem to have been Madhava's own contribution unless they are borrowed from texts no more extant. All matter has been integrated and arranged in a coherent and systematic manner. No wonder then that Madhava-nidana itself has been the subject of a large number of commentaries (Meulenbeld 1992:243-246). It has continued to be "an indispensable aid to physicians for over a thousand years". With Vagbhata and Madhava-kara, "Ayurveda became highly systematized, its pharmacopoeia expanded, and treatment procedures got refined" (Ramachandra Rao 1985 I:9). Madhava-nidana was translated into Arabic during the 9th century and into Italian in 1913-14.

Ayurveda-dipika (11th cent. CE). An influential commentary on Caraka-samhita, "widely relied upon by Indian physicians" is Caraka-tatparya-tika, better known as Ayurveda-dipika, composed by Cakrapani-datta (11th century CE), a native of Bengal. The Caraka we know is the Caraka constructed by Drdhabala and Cakrapani-datta. The latter also wrote an incomplete commentary on Susruta-samhita, called Bhanumati.

Nibandha-samgraha (12th cent. CE). The most celebrated commentary on Susruta-samhita, called Nibandha-samgraha, was composed by Dalhana (also spelt Dallana), who lived in 12th century CE, at a place called Ankola near Mathura. Dalhana was a practising physician, who travelled extensively to acquaint himself with popular knowledge about plants and details of their medicinal use. He incorporated local health care knowledge into formal texts by Sanskritizing many local plant names. In addition, he was a widely-read scholar. His justly famous commentary provides a wealth of other information as well.

Sarngadhara-samhita (CE 1226). A "short but solid text-book" is Sarngadhara-samhita, composed in CE 1226 by Sarngadhara. Prescriptions are copied from earlier works, but diseases are dealt with more elaborately Pulse examination (nadi-pariksha) for diagnostic purposes appears here for the first time. "This is the oldest work in which calcinations and similar metallurgical techniques are dealt with."

Bhava-prakasa (16th cent. CE). The most famous of the later texts is Bhava Misra's Bhava-prakasa, the oldest manuscript of which (now in Tubingen) is dated CE 1558. The text "repeats earlier accounts and formulae" but also adds new diseases and cures. Small pox (masurika) is described as "possession by the goddess Sitala", and an invocation to her included among the remedies. Notably, it is the first Indian text to describe syphilis, which is called phiranga ("foreigner"), and attributed to physical contact with the Portuguese.

Bhava-prakasa has a celebrated pharmacological supplement, called Bhava-prakasa-nighantu. It describes drugs (herbs, metals, foodstuffs, honey, etc.). It mentions use of Chopa-chini (dvipantara-vacha) to cure syphilis (firanga-roga).

Materia Medica

While the theoretical framework of Ayurveda has remained more or less the same, the knowledge about drugs has expanded. New things were learnt about old drugs, and incorporated into the texts by coinage of new terms and synonyms. Iksuraka was dubbed Kokilaksaka to denote "the colour and shape of seeds (Raghunathan & Dube:393). Kunkuma had been called Bahlika after its source of supply. Vagbhata called it Kasmiraja, to convey the important information that it grew in Kashmir also.

It was a common practice to prepare a drug directory-cum-handbook as an aid to the physician. When prepared as a stand-alone, it was called Nighantu, the term being borrowed from the Vedic literature.

The Vedic corpus names about 260 herbs (Kautilya'a Artha-sastra 330).The number increases to 385 in Susruta-samhita and to 500 in Caraka-samhita. The celebrated Bhava-prakasa-nighantu (16th century, referred to above) provides information on about 500 plant products of which about 400 are of actual drug value. There have been more recent compilations as well. Most of the physicians work with about 600 Ayurvedic drugs (Ramachandra Rao 1985 :75).

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Global Warming on Himalayan Ecosystem with special reference to Glacial lake Outburst Floods (GLOF)

Tarak Mohan Das

At the outset, one should admit that the geographical position of India is extremely vulnerable towards the onslaught of global warming. Almost three-fourth of its boundary line is contiguous with ocean and in the north there situates World's tallest and largest mountain range the Himalayas. Serious threats would come not only from the coastline, but also from the Himalayas embracing the vast river basin area of the Gangetic plain. Virtually due to the presence of Himalayas we have so long been enjoying congenial climate, enough water, high soil fertility, but due to human fault we are perhaps going to see the other face of the Lord Shiva, the cruel face of destruction, devastation and misery.

The length of the Himalayan ranges is over 1,500 miles. The snowline starts, on an average, from the altitude of 16,000 feet. Snows and glaciers have been stocked in various depths and dimensions on ridges and furrows of this vast area of the mountain ranges. A small fraction of the glacier melts and supplies enough water to the snowfed mountain streams and rivers. Due to rising of temperature if a major portion of the ice block starts to melt there may be incident of long lasting off season floods. A chain of catastrophic events may result in due to outburst of glacial lakes, the glaciers will gradually diminish in volume and ultimately the reduced water supply coupled with high temperature would pose serious threats to the entire forest cover of the Himalayan ranges as well as agricultural and horticultural productions of the Gangetic plain.

C_3 and C_4 plant species

Plant species can be divided into three groups based on their method of fixing carbon dioxide. These include the C_3 Calvin-cycle type (C_3, plants), the C_4 dicarboxylic acid cycle type (C_4 plants) and the crassulacean acid pathway type (CAM plants). Most of the evergreen and deciduous trees of the Himalayas and Himalayan horticultural fruit trees like apple, apricot, almond, pear, peach, plum, chestnut, walnut, cherry, strawberry and crop plants like rice, wheat, oat, barley, soybean, cotton, jute, tobacco, etc., are belonged to C_3 group. These C_3 plants are more adaptive to lower temperature, their optimal temperature range for photosynthesis is 10-25°C. Hence, their growth and yield would be severely reduced at high temperature. On the other hand, most of the weeds including grasses and sedges along with a

Table 1. Some of the Characteristics which distinguish Plants of High Photosynthetic Capacity (C_4 plants) and low Photosynthetic Capacity (C_3 Plants)[1].

Characteristics[2]	Capacity for Net Photosynthesis[3]	
	C_4 plants	C_3 plants
1. CO_2 compensation point	0-10 ppm CO_2	50-150 ppm CO_2
2. Photorespiration	Present only to a slight degree and therefore difficult to detect	Presented and easily detectable
3. Net rate of photosynthesis in full sunlight (10,000-12,000 ft.c.)	40-80 mg of CO_2 per dm^2 of leaf area per h	15-35 mg og CO_2 per dm^2 of leaf area per h
4. Response of net photosynthesis to increasing light intensity	Difficult to reach saturation even in full sunlight	Saturation intensity reached in the range of 1000-4000 ft.c.
5. Highly developed bundle sheath cells with unusual concentration of organelles	Present	Absent
6. Major pathways of photosynthesis CO_2 fixation	C_4-dicarboxylic acid and reductive pentose phosphate cycles	Only reductive pentose phosphate cycle
7. Temperature optimum for photosynthesis	30-45°C	10-25°C
8. Response of photosynthesis to O_2 concentration in the external atmosphere	Not inhibited in air (=21% O_2), as compared to an external atmosphere containing no O_2	Markedly inhibited in air (=21% O_2), as compared to an external atmosphere containing no O_2

few crop plants, like sugar cane, maize and Italian millet, etc., are C_4 plants. These C_4 plants physiologically and an atomically are more adaptive to high temperature. Their optimal temperature range for photosynthesis is 30-45°C. Hence, with the increase of global temperature these C_4 weeds with their better competitive advantages would create serious problems in the orchards and crop fields of C_3 plants. The crop loss due to the mite and other insect attacks may also be increased as the growth of these insects is generally favoured at hotter and drier climate. In order to cope with the global warming the agricultural scientists, specially the plant physiologists and crop breeders are advised to concentrate on the researches for raising temperature and drought resistant new cultivars of C_3 plants which could be grown under hotter and drier climate. Physiological and anatomical differences between C_3 and C_4 plants have been shown in Table 1.

Glacial lake Outburst Flood (GLOF)

Since the last few decades the International Centre for integrated Mountain Development (ICMOD) and its partner institutes have been surveying the glaciers and glacial lakes of Himalayan mountain range. World's largest mountain range covering six countries (India, China, Nepal, Bhutan, Pakistan and Afghanistan) is divided into three parallel rows, e.g., the Greater Himalaya is one the extreme north, Lesser Himalaya in the middle and Shivalic range is in the south. There are 800 peaks in Himalayas which are taller than 24000 feet. The total amount of snow and glaciers present in Himalayas is next to that of Antarctic and Arctic circles. The international Centre for Integrated Mountain Development (ICIMOD) along with its collaborating institutes have recorded as many as 15,003 glaciers and 8,790 glacial lakes. Table 2 will show the numbers and areas of glaciers and glacial lakes at different regions of Himalayas and the number of glacial lakes which are vulnerable and potentially dangerous for out bursting. It is observed that glaciers are retreating and melting at a much faster rate than usual. Huge quantity of water is accumulating in the glacial lakes. Due to mounting pressure of water a lake with unstable bank may be exploded partially or entirely causing devastating floods which is called glacial lake outburst flood (GLOF). In the past decades a number of GLOF events have been studied closely. Explosion may be mainly of two types, partial and total GLOF. When cracks are developed horizontally a partial release of water occurs at a very high pressure, but if the cracks are developed perpendicular to the base and at multiple spots, the entire lake may be exploded a chain of catastrophic event follows. An enormous amount of water with extreme pressure suddenly falling upon other glacial lakes causes their spontaneous explosion, creates new glacial lakes, causes multiple avalanches, landslides, destruction of mountain forests, roads, bridges, houses, and dams of the rivers. Ultimately, it ends up with the devastating flood in the river basin.

Table 2 will show that there are 203 potentially vulnerable glacial lakes exist at different regions of Himalayas, GLOF may occur with them at any time. Hence, various effective measures for mitigation are

Table. 2. Summary of Glaciers and Glacial Lakes in Himalayan Regions.

River Basins	Glaciers		Glacial Lakes		
	Number	Area (Sq. km)	Number	Area (Sq.km)	potential GLOF
India Himalayas					
Himachal Pradesh	2554	4160	156	385.22	16
Uttaranchal	1439	4060	127	2.49	0
Tista River	285	376	266	20.20	14
Pakistan Himalayas					
Indus Basin	5218	15040	2420	126.35	52
Tibet Himalayas (People's Republic of China)					
Ganga Sub-basins	1578	2864	824	85.19	77
Nepal Himalayas					
Nepal	3252	5324	2323	75.70	20
Bhutan Himalayas					
Bhutan	677	1317	2674	106.87	24
Totall	**5003**	**33341**	**8790**	**801.72**	**203**

Source : Survey Report of the International Centre for Integrated Mountain Development (ICMOD).

urgently required. But unfortunate truth is, most of them are situated at unapproachable regions and little could be done for their amelioration.

In fact, the entire Himalayas have been converted to an enormous manmade time bomb, which is almost impossible to diffuse. It is estimated that if the 30 of the 203 vulnerable glacial lakes outburst within a short interval of time, a vast area of agricultural land of the country present in the extensive basin area of three vital and perennial river systems, e.g., Sindhu, Ganga, Brahmaputra along with their branches would be totally devastated. It would create a perfect scenario of deluge. The whole episode of global warming including GLOF and its aftermath may be recorded in the history of mankind as a topmost manmade disaster, which in turn, may reduce the span of existence of many species of plants and animals including the growth of human civilization.

Aftermath of Deluge

Due to impact of global warming when most of the snow will disappear from the mountain top, mountain streams will start to dry up and its adverse effect on the Himalayan temperate forest ecosystem will be intense. The phytogeographical boundaries will be shifted with shifting of isothermal lines. The evergreen oak forests, coniferous forests, alpine scrub and meadows at higher altitude of the Himalayas will suffer most. They would perhaps be replaced with C_4 thorny hedges and grasses and similar other xerophytic plant species.

The Himalayas are said to be the home of about 3,000 endemic plant species. If these species lost their homeland, most of them perhaps would disappear from the face of the Earth. Many rare endemic species of orchids, *Rhododendrones, Saussureas, Primulas, Impetiens, Gentianas, Meconopsis*, etc., may become totally extinct. Trees of temperate and semi-temperate forests, e.g., *Abies, Acer, Alnus, Cedrus, Pinus, Taxus, Cryptomeria, Cupressus, Salix, Juniperus, Quercus* (Oak) associated with under growth and annuals with attractive flowering rhythm and unique ecological cycle, e.g., Brahma Kamal (*Saussurea obvallata*), Sow's ear (*Saussurea tridactyla*), Stuarts' primrose (*Primula Stuarti*), Musk thistle (*Carduus nutans*), Stalked gentians (*Gentiana stipitata*), Himalayan trumpet gentian (*Gentiana depressa),* Himalayan poppies, blue and yellow (*Meconopsis aculeata* and *M. robusta*), Wallich's poppy (*Meconopsis wallichii*), Himalayan lily (*Lilium oxypetalum*), Knotweed (*Polygonum affine*), Himalayan rose (*Rosa macrophylla*), Jocobs' ladder (*Polemonium caeruleum*), Himalayan edelweiss (*Leonto-podium stracheyi*) and numerous other cold loving plant species of Himalayan ecosystems would be seriously affected.

The deleterious effect of rising of temperature also will be visible on the yield of apples and other temperate fruit crops of Himalayas, e.g., almond, apricot, peach, plum, chestnut, walnut, strawberry and cherry, etc. At still higher altitude, above the present snow line, congenial low temperature may be available, but the limitations of water and soil cover would become the barriers for mass migration of these temperate species. Melting of snows and glaciers would expose the underneath bare rock surfaces and it would take many thousand years to build up suitable soil cover over there if other factors, e.g., water supply, temperature, microbial activity remain constant at a congenial level. Such disruption of primary productivity of the temperate forest ecosystem also would restrict the growth and distribution of consumers of all the orders. Many animal species of high altitude, like yak, ibex, snow-leopard, mountain goat, lynx, etc., can not tolerate high temperature, when yaks are brought down to the plains they develop a strange liver disease and die within a few months. All the snow loving consumers of the Himalayan ecosystems would become biological refugees and most likely would perish.

If global warming occurs, as observed by Peters and Myers (1991-92), that the ensuing ecological reorganization could be as great as the one at the end of last ice age, a time of mass extinction of species and reshuffling of biological communities. The IPCC* predicts that the most likely rate of warming will be one-degree rise in average temperature above today's by 2025 and three degrees before the end of this century. This rate would be 15 to 40 times faster than past warming periods. A three degree increase would make the Earth warmer than at any time in the past 100,000 years, and 4 degrees would make it the warmest since the – Eocene period, 40 million years ago. David Maddox, and ecologist with the Nature Conservancy, in collaboration with John Kartesz of the North Carolina Botanic Garden, USA concluded that if the Earth warms 3 degrees, climatic conditions would become unsuitable for roughly 20% of 14,000 native vascular plant species of USA. (For those plants already on the endangered or threatened lists for other reasons such as habitat destruction, the figure is 70%. Unless these species can migrate or be moved to suitable new habitat, they are likely to become extinct.

With a 3-degree rise of temperature, according to a moderate estimation of the present author, 70 to 80 per cent of plant species of the Himalayan forests would find the climate extremely hostile and unsuitable for their existence. But the most tragic part of the drama is – there would be hardly any place available for them for natural migration unless they adapt themselves with changing climate. Such possibility for adaptation perhaps is greater among the short lived herbs than that of valuable tree species. Shorter life cycle permits a more rapid evolutionary development through a more rapid genetic turnover. Many new species also may be evolved. But a long time span would be necessary for such adaptation, speciation and stabilization.

The Strategy for Mitigation

In order to mitigate the greenhouse effect a number of international strategies have been put forward and hotly debated in Rio Conference in June 1992. One such strategy, as formulated by Mick kelly of the Climatic Research Unit in the School of Environmental Science at the University of East Anglia, England, is as follows :

1. A 30 per cent reduction of carbon dioxide emission from burning of fossil-fuels from the present amount by the year 2020.
2. A 25 per cent reduction of accumulation methane and nitrous oxide in the atmosphere by the year 2020.
3. A ban on the production of CFCs and halon and avoidance of other compounds that may produce greenhouse effect.
4. A halt of deforestation by the year 2000, followed by extensive reforestation, which could absorb 1.6 billion tons of carbon dioxide from the atmosphere per year.

Growing human number place greater demand on fossil-fuel, food and forests. It seems almost impossible to implement this strategy unless we restrain our demand by reducing the population growth successfully. The present growth rate of human population is beyond the bearing capacity of this planet. In fact, it is a challenge to our survival, perhaps we have to alter our life-style altogether to cope with the changing climate in future.

The figure 1 shows that the global warming may be halted and stabilized around the year 2050 if the aforesaid strategy is followed by all the nations. The upper limit for such stabilization 2.5°C, lower limit 1.0°C and the average 1.75°C increase from the pre-industrial norm. Even such average limit of rising temperature, according to experts, may cause such a shift to climate change which is unseen and unprecedented in human civilization.

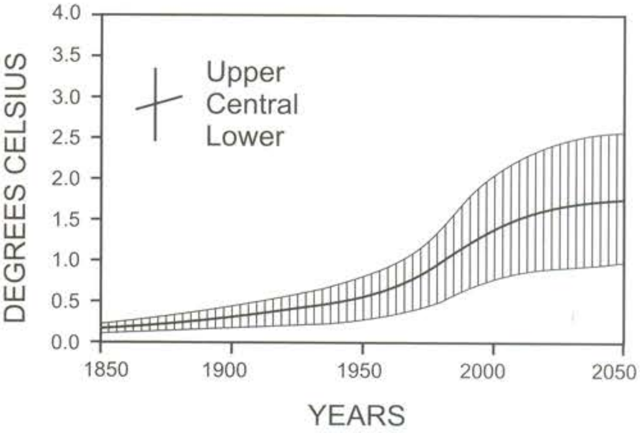

Fig. 1. Global warming may be halted and stabilized around the year 2050 if an international strategy is implemented rigorously. Upper line of projection indicates the maximum limit (2.5°C), lower line for the minimum limit (1°C) and the central line denote the average (1.75°C) increase of temperature from the pre-industrial norm.

Influence of Other factors

Virtually all scientists agree that if the emissions of greenhouse gasses are not controlled and all other factors remain the same, the Earth will warm up. But the crucial issue is to what extent other factors remain the same. With slight climatic change host of other factors would start to play their role simultaneously and many of them may work in favour of keeping the climate in an equilibrium. Critics of the greenhouse effect argue on following points :

The ocean and oceanic planktons have enormous capacity to absorb carbon dioxide. Past geological history and fossil records show that many times over millions of years the Earth faced large-scale volcanic activity which had loaded the atmosphere with carbon dioxide and heated the climate. Oceans themselves did act as biophysical buffer system. Along with the absorption of carbon dioxide by oceanic water the population of phytoplankton as well as micro-foraminifera and other shell forming organisms increased many folds. These oceanic creatures took carbon dioxide and used the carbon to make their protective shells. When the organisms died, their shells sank to the bottom of the ocean, locking the carbon away in mineral deposits that one day would rise from the sea as white chalk cliffs. A vast coastal area of England is crowded with lofty chalk cliffs which indicates that long time ago the climate of this region was warmer and carbon dioxide in the atmosphere was plenty. Almost similar history about the dolomite cliffs of Northern Italy and Austria, which stand majestically dominating the sky line of these countries, the height of the highest dolomite peak is over 3,000 metres. Dolomites are the double carbonates of calcium and magnesium, their origin was from warm, shallow sea water.

These chalk and dolomite cliffs are the products of greenhouse effect of the past. Hence, in future, in a similar way the greenhouse effect would be mitigated, critics are apprehending. But it should also be borne in the mind that deficiency of iron and high pollution level on the continental shelf would pose a serious impediment against such unlimited growth of these oceanic creatures in future.

1. After Black, 1971 (Table 1).
2. These characteristics apply to fully differentiated tissues only.
3. All comparisons are at 21% oxygen, 0.03% carbon dioxide, or otherwise as near physiological conditions as possible.

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Open Innovation: A New Paradigm in Science and Technology

Tushar Chakraborty

Secrets are edged tools
And must be kept from children and from fools
John Dryden[1]

Science is not as open and unguarded as the common man assumes it to be. Both openness and secrecy in one form or another remains associated with science, wherever or whenever it is practiced. Science is thus a part open – part secret activity. This is one of the fundamental contradictions in science. The recent upsurge of open innovation and open access to science movement is partly a reaction to this key problem.

But why this duality of openness and secrecy gets into science is a much big and complicated issue. There is perhaps no single answer to it. Looking back at its origin, one school of thought suggests that the science evolved from magic, and thus secrecy was a hallmark of all proto-science activities. They say; perhaps, that legacy is still being continued. The history of pre-modern science related activities, and cultural milieus that bred such activities, both in East and West, bears ample testimonies to this concept. But, how about modern science?

We all know that modern Science exalted openness as one of its most cherished intrinsic and essential quality. While defining ethos of modern science Robert Merton referred communism, or common-sharing of everything, one of its central axiom[2]. But, opponents argue, that in real or actual practice, this attitude is not at all universal in science. Indeed, Mertonian "communism" and other ethos of science largely remained as an ideal situation in its day to day practice (Fig. 1). Hence, one can surely ask the question, what constitutes openness in science in real world today, and what encourages its secrecy?

Fig. 1. Robert King Merton (1910-2003)

Secrecy: the dark side of science

Although, free and open exchange of ideas are rhetorically held as sacred by almost every scientific and science institutions in the world, to protect their own interest - secrecy gets a sacred sanction by the very same institutions. In practice, secrecy and openness are so interdigited in science that we can easily call secrecy – the inseparable dark side of science. At least 3 impetus of secrecy we can recognize easily. We will introduce them briefly, one by one.

Firstly, the modern science is a highly competitive game. Winning the game, and to stay ahead of others, is very important in almost all scientific practice. Hence, in the desire to protect their own interest and to insulate them from the risk of competition – practitioners of science often withheld vital information regarding their discovery or innovation. Thus, competition breeds secrecy.

The second factor contributing to secrecy in science is the commoditization of science. Ideally, only invention needs to be protected – but discovery and innovation are supposed to be of open access to all. But, as upstream and downstream activity to invention – discovery and innovations too are usually protected and guarded heavily in science. Wherever – industry is involved in science, or has interest in its deliverables – this is a rule, rather than the exception. Even knowledge from open public domain or traditional knowledge domain is often gets misappropriated by the Industry through patents and IPR laws (by bending those laws). Thus, openness gets a beating!

Fig. 2. Daniel Patrick Moynihan (1927-2003)

The third factor promoting secrecy in science comes from the side of the government. Daniel Patrick Moynihan (Fig. 2), the Democrat senator in US Congress once said, an inspection of government classified information in 1997 in US led to an official count of more than 6.6 million secrets, of which only 1.5 percent is related to atomic energy statutes! The United States Government is not alone in this game. All state power throughout the world promotes secrecy. Moynihan bluntly acknowledged, that the real cost of this massive effort to keep information from the American people is really "clogging up" open debates and exchanges of information in united states - that are essential for democracy to work. We know – openness is essential for science as well. One reason why Japan could beat US in the innovation game in pre-globalised 20th century technology war is – Japan's miniaturized basket of government secrets. Compared to US, Japan kept their state protected secrets it minimal and effective.

This experience is vital. A main focus of science and technology studies is to unravel its mechanism. In doing so, highly organized current science in advanced nations have been often described by many as a triple helix, where Academy, Industry and Government intermingle with one other[3]. As both Industry and Government normally promote secrecy - unless open access is prioritized – in long term, triple helix might typically deter science. The rise and fall of Japan in innovation game reflects the short-term achievements of triple helix and its long-term decline. The analysts believe that the sluggish after effect of triple helix, after its initial bump and slump, is almost inevitable in any state or society.

Globalization: Resurgence of Openness

Although barriers to openness exist, science often tries to transcend those barriers. The era of globalization, in certain sense, improved the chances of such transcendence. Such macro-level adjustment between globalization and openness exist, and it is no secret. It is largely a corporate culture driven change, which directly undermines state – apparatus. In this sense, globalization can be seen as an openness initiative in mega scale. Open innovation is the buzzword which captures and expresses this transition. Transition from local to global, national to international is its goal. However, micro level operatives of globalization are not so visible. The world today is complex, uncertain and dynamic. It is in constant flux. The key survival strategy in this world in flux is to innovate and change.

We will take a very brief look here at few such agendas of openness initiative.

Open Innovation Model

Henry Chesbrough of Haas School of business in 2003 has published a book entitled, Open Innovation: The new Imperatives for creativity and profiting from technology[4] which exposes how the game of innovation has changed in this new global era. The companies that don't innovate are destined for death in this era. In one sense, this is the crux of the matter in so called "Knowledge Economy" (Fig. 3).

The innovation today has taken a new turn within the corporate R&D laboratories. The essence of such R&D practice used to be the controlled environment. That controlled environment idealized the real world at macro level, by averaging out variations and local discrepancies arising from the micro-cohorts, and individual identities. The goal of today's innovation is to become local and personalized. Globalization today is different from all previous globalization in colonial era in this inward journey. The ICT (Information and Communication Technology) has provided the means to capture enormous amount of data, and to invade privacy – in a way, which was hitherto unthinkable. To cope with this new challenge – the laws related to IPR or the Intellectual property right is being changed to make better impetus in the new economic landscape. Thus, laws of copyright previously applicable for only literary works such as books, cultural items such as music, tapes, records etc are now extended to software and integrated circuits. The patent laws in USA were granted to the first to discover, not the first to file previously. This naturally used to generate numerous court case or law suits. Now a debate has started, whether patents should be issued to the first to file, which is the practice in the rest of the world.

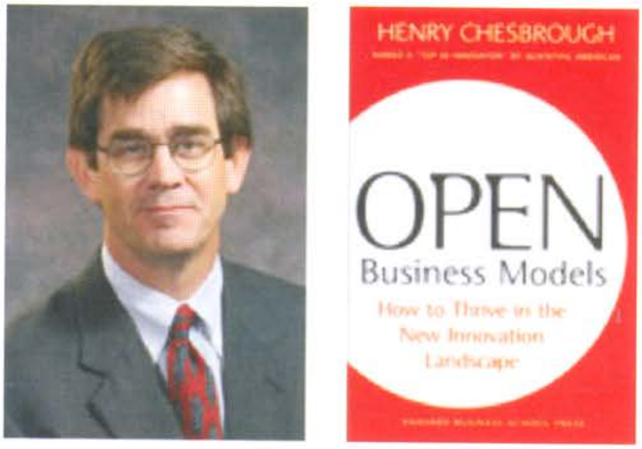
HENRY CHESBROUGH
OPEN
Business Models
How to Thrive in the New Innovation Landscape

Fig. 3. Henry Chesbrough.

Is this reformative mood in US IPR arena symbolizing a decline in US innovation edge? And if so, the actual impetus of open innovation paradigm may not be simply its so called democratizing and universalizing urge. Rather, there may be a hidden tendency in it to invade and capture innovation coming out of emerging economies – such as China or India.

Science for Science's Sake

The overall situation in the western world regarding science and society is at present utterly confusing. The transition from industrial capitalism to knowledge based economy of corporate mercantilism has created this murky atmosphere. Rule of the game in science and technology is changing. Publication business – one of the important pillars of scientific enterprise has already internalized the message and signalling this transition. The old adage of science for science's sake is no longer valid to them. For last two decades, post-modern critics relentlessly tried to put science as a social construct. However, their efforts were largely in vain. Suddenly, after the great depression mark-2, this has now become accepted as the main-stream ideology. Natural Science, Biological Science, mathematics, and social science were never as close – as it is today. Even specialized scientific journals are now carrying special sections on societal issues. Publication and media policy will undergo further reform in coming days. The high level political appointees from the government and from the corporate agencies will be the harbinger of this new approach. You will see openness in them and that will percolate to the rank and file STEMM (Science, Technology, Engineering, Medicine and Management) personnel.

Biotechnology: US and the Rest

If we agree that Innovation is associated mostly to the part of economy which is fast moving, futuristic and a source of wealth and power then Biotechnology is the logical centre of this new age innovation. United States is the big player in this art since its inception. We can safely state - The empire of biotechnology is a more or less a US empire. The triple helix model of academy – industry – government tripartite, three stranded, intertwining collaboration axis is the dominant managerial model in US led biotechnology industry.

Bio power and bio politics however has attracted the intellectuals of all hues and colours, be they be Red, Green, Yellow or Saffron. Almost everyone has a say on this. However, very few actually recognize how US has build-up this biotech empire. United States is unique in its public spending of health, where molecular biology and biotechnology gets priorities since shortly after World War II was over. Actually, US created this branch of science and technology with a long term vision. The U.S. allocates more funds on health research, as a fraction of its gross domestic product, than any other nation. And a large fraction of this funding promotes its ever-growing the Biotech endeavours. The relative funding in engineering, chemistry, or physics followed quite a different trajectory in US. Actually, other western countries, and Japan or Korea have in that period allocated a higher fraction of their GDP devoted to physical and engineering sciences compared to America. The stark difference was almost qualitative. The backdrop of decline in US industry was created by this policy, where pharmaceutical research and manufacturers occupied the centre stage in US biotech venture.

Due to real progress as well as prize and propaganda, public opinion in US regarding biotechnology is very different, compared to the rest of the world. This creates a pseudo-open environment and ambience in US on around modern biology and biotechnology. A section of the conservative politicians know this inside story – and some of them were staunch opponent of this policy on religious and moral ground. They were annoyed too by the slow progress and lack of net profit from biotechnology based industries.

Biotech India: OSDD or the Triple Helix Model?

A sizable section in Biotechnology Industry in India wanted to copy the US biotechnology model, lock-stock and barrel. Currently, this section is leading Biotech sector in India. In the long run, how far this imitation can go – and what it can deliver to the public – only time will tell. The open source drug discovery (OSDD) model, focussing on TB and other neglected disease is one exception in the overall scenario[5]. This is a model, based on open innovation. OSDD is a CSIR-led team India consortium with a global partnership. Its vision is to provide affordable healthcare using global platform where the best minds can collaborate & collectively endeavour to solve the complex problems associated with discovering novel therapies for neglected tropical diseases like malaria, tuberculosis, leishmaniasis and other diseases. It is a concept to collaboratively aggregate the public database on biological and genetic information. This may provide a unique opportunity for scientists, doctors, technocrats, students and others with diverse expertise to work for a common cause.

The recent success of open source models in Information Technology (For e.g. Web Technology, The Linux Operating System) and some Biotechnology (in Human Genome Project) sectors highlights the urgent need to initiate a similar model in healthcare. Herein lays the genesis of this open source model for drug discovery (Fig. 4).

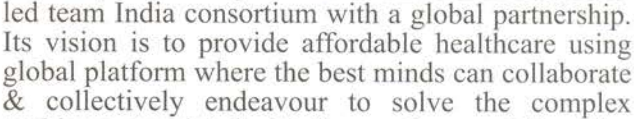

Fig. 4. CSIR, promoter of OSDD utilizing Genome Information.

The Government of India has committed Rs.150 crores (US$38 million) towards this project. An equivalent amount of funding would be raised from international agencies and philanthropists. About Rs.46 crores (US$12 million) has been already released by the Government of India[5].

Which model will dominate the Indian biotechnology future - the Triple – helix model or OSDD is an undecided, open issue.

Conclusion:

Secrecy in science sounds enigmatic, sinister and alarming. Yet, action of secrecy is a reality in the very domain of science. Scientific spirit as reflected in the openness of science seriously deteriorated under late age industrial capitalism due to such operation of multilayered secrecy. This created tensions, and harmed the scientific integrity. Now, we have both a chance and the necessity to change this milieu. Let us not forget that the organized scientific activity is nothing but a visible or invisible teamwork to understand nature - which can best perform only in an open platform[6].

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Science communication through print media

Biman Basu

Before the invention of printing, dissemination of ideas and thoughts took place mostly through handwritten manuscripts. Indian palm leaf manuscripts and Chinese writings on silk are well known. Modern printing technology had its origin in Europe. German goldsmith and printer Johannes Gutenberg was the first European to use movable type printing, in around 1439, and also the global inventor of the printing press. His many contributions to printing include the invention of a process for mass-producing movable type; the use of oil-based ink; and the use of a wooden printing press (Fig.1). He combined these elements into a practical system which allowed the mass production of printed books economically. The use of movable type was a marked improvement on the handwritten manuscript, which was the existing method of written communication in many parts of the world.

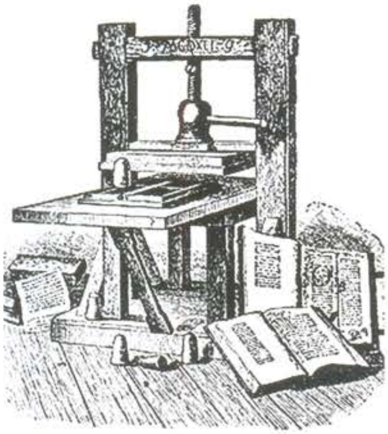


Fig. 1. Gutenberg Press.

Science communication

Science communication can be defined as "successful dissemination of scientific and technological knowledge among a wide range of audiences including non-scientists". There are numerous examples of effective science communication having brought about social change that have transformed the world. From the Copernican Revolution to the Laws of Thermodynamics to the Theory of Relativity, communicating science has historically and will continue to change the world. So effective communication of science is probably as important a skill as learning how to do science, and print media provide a viable mode of mass communication of science.

Science communication through print media could be for a peer science audience or the general public. Scholarly writing involves providing scientific context and lots of text, little graphics, and is focussed on results, data, and interpretation. On the contrary, science writing for a much broader audience is primarily aimed at disseminating information in a non-technical language and creating awareness. The focus is not on results, but rather on the conclusions and recommendations, and social implications if any. In recent years there has been tremendous diversification of communication media, especially with the growth of ICT-based systems, which has made information easily accessible. Notwithstanding these developments, printed journals, magazines and books continues to remain highly effective media for science communication. Although most journals and dailies, and even books are now available online in digital form, they are basically the electronic version of print editions.

Research communication

Communication of science among scientists is very important for the advancement of science and technology. This usually happens in a very systematic and methodical manner through technical sessions, symposia, proceedings and peer reviewed articles in scientific journals. While the research findings from labs need to be communicated to scientists as well as the common man, the styles differ widely. Most researchers communicate through research journals with their peers and other scientists in the respective fields. In contrast popular science communication is primarily targeted at the common man who need not necessarily have any background of science.

The style of writing a research paper is mostly guided by the 'house style' of the journal in which it is intended to appear. Further, the modern scientific paper is a rigidly stereotyped document, with well-defined sections following each other, e.g., Introduction, Methods, Results, Discussion and/or Conclusion, References, together with a relatively free-standing Abstract. While such constraints undoubtedly provide a standardised format and make the task of writing a research paper simpler, it takes away from the writer the freedom to express in his or her own style.

A paper written for publication in a research journal is primarily aimed at other scientists/researchers in the same field. Consequently, technical terms and expressions, equations and mathematical data can be freely used where necessary. This makes the task of writing a research paper comparatively simpler than writing popular science, in which use of technical jargon is a taboo. A research paper has to bring out the objective, experimental procedure, observations, and inferences and results without any ambiguity, which makes a good command over the language of writing an essential prerequisite.

A well-written research paper is able to convey a lot through judicious use of less words. A classic example is the paper on DNA structure by James Watson and Francis Crick published in *Nature* on 25 April 1953. It was a one-page paper but contained the germ of a whole new world of biotechnology and genetic engineering that has revolutionised the study of biology.

Watson and Crick wrote in their paper:

> We wish to suggest a structure for the salt of deoxyribonucleic acid (DNA). This structure has several novel features which are of considerable biological importance. ......This structure has two helical chains each coiled round the same axis. ....The two chains (but not their bases) are related by a dyad perpendicular to the fibre axis. ....The novel feature of the structure is the manner in which the two chains are held together by the purine and pyrimidine bases. The planes of the bases are perpendicular to the fibre axis. They are joined together in pairs, a single base from one chain being hydrogen-bonded to a single base from the other chain, so that the two lie side by side with identical z-coordinates. One of the pairs must be a purine and the other a pyrimidine for bonding to occur. ....
>
> .....It has not escaped out notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material. ....

Here the two scientists could bring out the tremendous potential of their discovery unambiguously in just a few words in the last sentence, which speaks of their ability to communicate science precisely and with brevity.

The modern professional pattern of specialised academic journals containing stereotypically structured research papers is not very old; it only matured in the twentieth century, following on the line of a few proto-journals of the Royal Society and other early learned societies. Historically, early scientists (who were known as natural philosophers) preferred writing monographs rather than publishing papers in journals to establish claim for new knowledge. To meet the cost of printing, early printers and publishers required authors to obtain sponsorship (especially for expensive illustrations), or get up a list of subscribers who would pay for the volume in advance. Many of today's research journals too, levy page charges from authors for publishing papers.

Scientific and medical journals started as newsletters aimed at disseminating matters of interest to the community and were not exclusively devoted to publishing fresh research. Specialised journals, reflecting the fragmentation of science, started appearing only from the late eighteenth century. Initially such journals were mostly published by learned societies, whose lectures and proceeding provided the contents. Science journals eventually became the standard media for primary reporting of new research aimed at meeting the increasing pressure of claims for new knowledge from an increasing number of working scientists.

Before the advent of computers and desktop publishing, every research paper had to go through meticulous proof-reading after typesetting, before the pages could be sent for printing. Proof-reading was not only a tedious process that was time consuming, but it was also not completely foolproof. Often typesetting mistakes went unnoticed. As a result authors often had to make corrections more than once, which delayed the publication of a paper.

Today the situation is quite different. Authors are required to send error-free copy of the paper which obviates the need for proof-reading. Some journals even accept papers only if submitted in the same format the journal is printed so that the printer only has to use camera for making the plates for printing. These advances have made possible faster publication of research papers by significantly cutting down the time lag between acceptance and printing.

Popular science communication

Peer-reviewed articles are often the litmus test of a researcher's success, determining tenure or 'fundability'. If the only goal of research is to influence the state-of-the-art, targeting only other researchers, then this is the ultimate objective. However, if the research has to have any impact on society by changing or influencing policy, mere publication of a paper in peer-reviewed journals would be woefully inadequate, because beyond scientists and academics, the readership of scientific journals is effectively zero. Decision-makers do not read them. Neither do the media or communities. The language of scientific journals often makes it impossible for the lay person to understand the research. Here lies the importance of popular science communication and the print media plays a major role here.

Popular science writing does not follow any standardised format. The writer has the complete freedom to express his/her thoughts in whatever way he/she feels fit. That is why many popular science writers can be identified by their style of writing. This makes popular science communication more varied than research communication.

There are several formats in which popular science communication through print media can be done. It may be a straight article or essay, an interview, or even a photo feature or cartoon strip (Fig.2). There are even poems and drama/skit written on science themes that provide a novel and effective mode of communicating science.

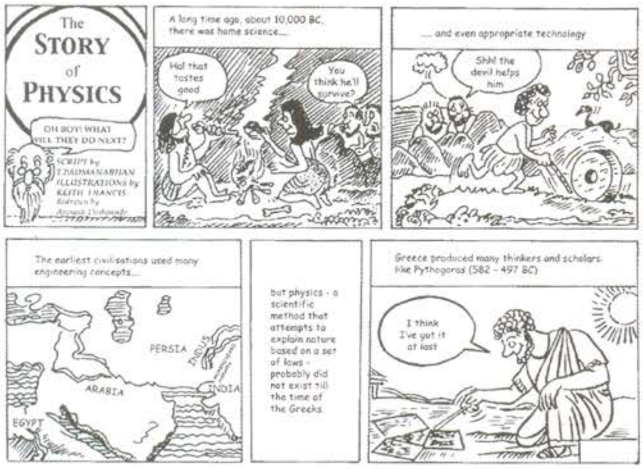

The STORY of PHYSICS
OH BOY! WHAT WILL THEY DO NEXT?
SCRIPT by T.PADMANABHAN
ILLUSTRATIONS by KEITH FRANCIS
A long time ago, about 10,000 BC, there was home science...
Ha! that tastes good
You think he'll survive?
... and even appropriate technology
Shh! the devil helps him
The earliest civilisations used many engineering concepts...
PERSIA
INDUS
ARABIA
INDIA
EGYPT
but physics - a scientific method that attempts to explain nature based on a set of laws - probably did not exist till the time of the Greeks
Greece produced many thinkers and scholars like Pythogoras (582 - 497 BC)
I think I've got it at last

Fig. 2. Science cartoons.

Print media for popular science communication can be basically of three types, each with its strengths and weaknesses. Daily newspapers offer the fastest print medium for coverage of scientific events, but are constrained by limited space availability, cursory coverage and ephemeral value. There is little scope of detailed discussion on any topic in a newspaper article. Weekly, fortnightly and monthly magazines offer a better alternative in terms of coverage and treatment, but there is a time lag of up to a week or more between submission of an article and its publication. Magazine articles have intermediate value. Books offer a medium for the most comprehensive treatment of a scientific topic. The author has ample room for delving deeper into the subject and bringing out the salient points in a more leisurely manner than possible with either a newspaper or magazine article. Books have lasting value (Table 1).

Table 1. Print media

Dailies	Only cursory treatment possible	Of ephemeral value
Periodicals	More detailed treatment possible	Of intermediate value
Books	Most comprehensive treatment possible	Of lasting value

Daily newspapers

Daily newspapers are often the first source of news about a new scientific development for the common man. Articles in newspapers – news items, features or editorials – reach a wide audience and can generate public debate. The print media in the form of newspaper can thus inform the public about research being carried out in different scientific institutions and labs and help in better public understanding of the research.

The style and format of a newspaper article is markedly different from an article in a scientific journal. In the case of a newspaper article, not only must the title grab the reader's attention, but the article itself should be constructed like an inverted pyramid, starting with the most important information and working down to the individual supporting details. While this applies more to a news story than to a fuller feature article, the logic is important to understand.

Unfortunately, despite their wide reach, the space devoted to science in Indian newspapers is insignificant. While a few Indian newspapers publish weekly science columns and have regular science correspondents or science editors in the staff, items on science and technology published in Indian newspaper mostly are based on press releases and agency stories.

Few studies have been done on coverage of science in newspapers and its impact on public perception of science. In a study carried out in 2000 by Bharvi Dutt of National Institute of Science, and K. C. Garg of NISTADS, items on science and technology in English-language newspapers published in different parts of India during January-December 1996 were analysed. Results indicated that the greatest proportion of newspaper space was devoted to nuclear science and technology, followed by defence, space research, and astronomy. *The Pioneer*, *The Hindu*, and *The Times of India* were the newspapers that together accounted for about 23 percent of the total space devoted to items on science and technology. The sources for most of the articles (97 percent) on policy issues originated from within India, while for other stories foreign sources, including those from the United States and the United Kingdom, also contributed. The study indicated that, on average, Indian newspapers devoted far less than one percent of the total printed space to articles and stories related to science and technology. This situation needs to be improved.

Popular science magazines

Compared to daily newspapers, the scope of popular science magazines as a medium of science communication is manifold. However, from commercial and economic considerations sustaining a popular science magazine is often an uphill task for the publisher. The constraint is mainly financial. Advertisers do not consider popular science magazines viable media for advertising, although the readership of a few popular science magazines is quite large. As a result, most of the popular science magazines published in India, like *Science Reporter* and *Vigyan Pragati*, both published by Council of Scientific and Industrial Research and having reasonably large readerships, are heavily subsidised. Another popular science monthly *Dream 2047*, published by Vigyan Prasar, an autonomous organisation under Department of Science and Technology, is distributed free to interested readers. It has built up a large circulation and continues to be in great demand, as evident from mail received from readers. *Science Today*, a widely read popular science monthly published by the Times of India group, and *Science Age*, another widely read popular science monthly published by Nehru Centre, Mumbai, carried top class popular science articles. Both had to close down in view of financial unviability.

There are a few popular science magazines published in a few regional languages including Hindi, Bengali, Odiya, Malayalam, Tamil, Telugu, Marathi, Assamese, to name few. But most have meagre circulation and are partly subsidised.

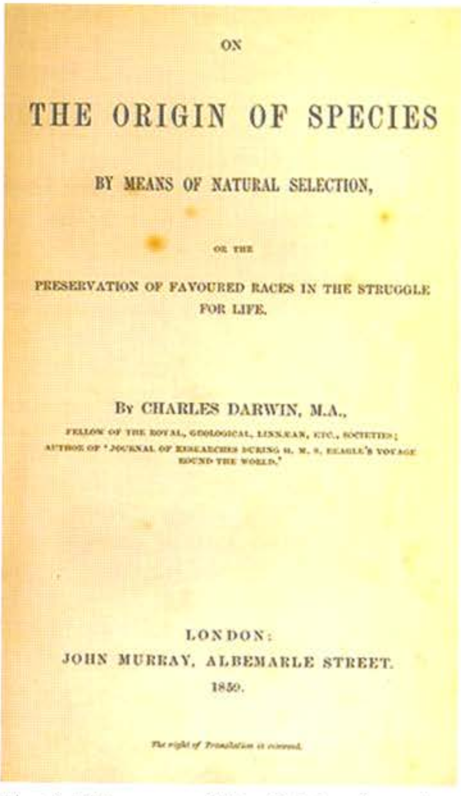
Quite a few foreign popular science magazines such as *Discover*, *Scientific American*, *Science Illustrated*, and *New Scientist* are available in India, as is *National Geographic* magazine which often carries excellent popular science articles. But all are quite expensive by Indian standards and are beyond reach of the average Indian reader.

Despite being one of the most effective modes of popular science communication for non-specialists, the cost of producing popular science magazines in India is quite high, which makes keeping the price low a difficult proposition unless heavily subsidised. This constraint can be removed if the Indian private sector comes forward to take up publishing of low-priced popular science magazines as a social responsibility.

Popular science books

By their very nature, books offer a unique platform for communicating popular science provided by no other print medium in terms of detailed treatment possible. Popular science books have been at the forefront of science popularisation for more than a century.

Charles Darwin's *The Origin of Species*, published in 1859, was a trend setter in popular science communication (Fig.3). The book was written for non-specialist readers and attracted widespread interest upon its publication. In his book, Darwin introduced the scientific theory that populations evolve over the course of generations through a process of natural selection. It presented a body of evidence that the diversity of life arose by common descent through a branching pattern of evolution. Darwin included evidence that he had gathered on the *Beagle* expedition in the 1830s and his subsequent findings from research, correspondence, and experimentation.



ON

THE ORIGIN OF SPECIES

BY MEANS OF NATURAL SELECTION,

OR THE

PRESERVATION OF FAVOURED RACES IN THE STRUGGLE
FOR LIFE.

BY CHARLES DARWIN, M.A.,

FELLOW OF THE ROYAL, GEOLOGICAL, LINNÆAN, ETC., SOCIETIES;
AUTHOR OF 'JOURNAL OF RESEARCHES DURING H. M. S. BEAGLE'S VOYAGE
ROUND THE WORLD.'

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1859.

The right of Translation is reserved.

Fig. 3. Title page of The Origin of species.

The lucidity of his text can be judged from the introduction he wrote for *The Origin of Species*. Darwin wrote:

> When on board H.M.S. *Beagle*, as naturalist, I was much struck with certain facts in the distribution of the inhabitants of South America, and in the geological relations of the present to the past inhabitants of that continent. These facts seemed to me to throw some light on the origin of species – that mystery of mysteries, as it has been called by one of our greatest philosophers. On my return home, it occurred to me, in 1837, that something might perhaps be made out on this question by patiently accumulating and reflecting on all sorts of facts which could possibly have any bearing on it. After five years' work I allowed myself to speculate on the subject, and drew up some short notes; these I enlarged in 1844 into a sketch of the conclusions, which then seemed to me probable: from that period to the present day I have steadily pursued the same object. I hope that I may be excused for entering on these personal details, as I give them to show that I have not been hasty in coming to a decision.
>
> .... In considering *The Origin of Species*, it is quite conceivable that a naturalist, reflecting on the mutual affinities of organic beings, on their embryological relations, their geographical distribution, geological succession, and other such facts, might come to the conclusion that each species had not been independently created, but had descended, like varieties, from other species. Nevertheless, such a conclusion, even if well founded, would be unsatisfactory, until it could be shown how the innumerable species inhabiting this world have been modified so as to acquire that perfection of structure and co-adaptation which most justly excites our admiration.

As Darwin was an eminent scientist, his findings were taken seriously and the evidence he presented generated scientific and philosophical discussion. But more than that, it showed the power of the printed word in changing the mindset of people.

In India, eminent personalities like Rabindranath Tagore, Bankim Chandra Chatterjee, Jagadish Chandra Bose, Satyendranath Bose and many others wrote excellent popular science. Tagore's *Vishwa Parichay*, and J.C. Bose's *Avyakta* are outstanding popular science books that enthralled a whole generation of young readers in Bengal. In recent times the works of Jayant V. Narlikar, D. Balasubramanian, Bal Phondke, G. Venkataraman, have become best sellers. Among notable international popular science authors, George Gamow, Isaac Asimov, Arthur C. Clarke, John Gribbin, Richard Dawkins, and Richard Feynman have wide readership in India.

As is the case with popular science magazines, the price of foreign books in India is usually high, although Indian reprints of many titles are available at low price. To make popular science books available at affordable cost, several government agencies have taken up popular science book publishing. Notable among them are National Book Trust, Vigyan Prasar, Publications Division, and National Institute of Science Communication and Information Resources (NISCAIR), a unit of the Council of Scientific and Industrial Research. Among themselves these organisations have brought out excellent popular science books that have gone into several reprints.

Graphics in print media

Tables, graphs, diagrams, and sketches or photographs are essential components of a research paper, popular science article, or a popular science book. In the past every illustration and diagram had to be hand drawn, which was not only time consuming but also could not provide uniform quality. Techniques of making scientific illustrations have undergone sea change with the advent of various computer graphics software. Be it the structure of a complex molecule, a bar graph or pie chart, there is computer software available that can easily convert data into the required graphics.

Before the advent of the present digital age, processing of graphics material for printing involved the complex and expensive method of block making. Colour illustrations necessitated multiple block making that greatly increased the cost of printing. Moreover, once a block was prepared there was no scope of modification – a reduction or increase in the size of an illustration to fit the available space in a page. Modern techniques of digital scanning and processing have totally eliminated these constraints. Photographs and diagrams can be processed at any stage – even after the page is made up – to make final modifications.

Modern printing technology

Be it daily newspapers, journals and magazines, or books, printing technology has also undergone a revolution across the world. Gone are the days of setting type by hand or machine. The traditional system of galley proofs and art pulls are totally eliminated. Typesetting is universally done today on computer and pages made up using a variety of software such as PageMaker or CorelDraw. In a publishing house the error-free text matter and graphics are directly imported to the DTP station for page making and final made-up pages with text and graphics are delivered for plate making and printing. Printing is often carried out as a large-scale industrial process, and is an essential part of publishing and transaction printing.

Books, magazines, and newspapers are printed today using the technique of offset lithography (Fig.4). In this technique the inked image is transferred from a plate to a rubber blanket, then to the printing surface. When used in combination with the lithographic process, which is based on the repulsion of oil and water, the offset technique employs a flat image carrier on which the image to be printed obtains ink from ink rollers, while the non-printing area attracts a water-based film, keeping the non-printing areas ink-free. Offset printing has not only made the printing process faster but has also significantly improved the quality of printing, especially colour printing of popular science magazines and books.

Fig. 4. A modern offset printing machine.

Print media vs electronic media

While science communication through print media has existed from olden days and still continues to be quite effective, the spread of electronic media has brought in a new dimension in the technique of science communication. The Internet today provides almost instant access to almost any kind of information including scientific information that the print media cannot provide. At the same time, however, the convenience of reading that a printed newspaper, magazine or book can provide is not available with the electronic media such as e-readers and iPad that often involves access to the Internet and is powered by battery. Besides, constant reading on the screen that can be quite tiring for the eyes.

Nonetheless, in view of the quick accessibility the Internet provides compared to the print media, most daily newspapers and many research journals and popular science magazines are today available in digital form on the Internet. But in most cases the matter appearing online is the same as in the print editions. In this respect the electronic forms can be considered only an extension of the printed form, although in terms of faster accessibility the electronic media is ahead. That is why many scholarly journals as a rule have advance online publication before they actually appear in print in the journal. This gives researcher faster access to new research not possible through print media.

Despite the faster accessibility of information compared to the print media, research has shown that comprehension, especially of popular science, is better with printed material compared to online reading. A study by Mônica Macedo-Rouet *et al.* of Methodist University of São Paulo, some years ago to determine the effects of print and online presentations of a multiple document report on reader's comprehension, perception of cognitive load, satisfaction, and attention revealed that users of online media show poorer results compared with print users. An experimental protocol was used to assess readers' performance using print and online versions of a popular science magazine. The researchers found that hypertext led to higher perceived cognitive load and poorer comprehension of the complementary documents. The results suggest that presenting graphics in long hypertext increases effort and reduces text legibility. The data supported theories of disorientation and cognitive load in hypermedia learning. In a way, online reading with too many hyperlinks can be said to cause 'information overload' that often distracts the reader from the main topic and reduces comprehension.

Conclusion

Despite the spread of the Internet and electronic publishing, the print media is likely to hold sway as a powerful vehicle for science communication - especially popular science communication - for several reasons. Electronic media is no doubt becoming the preferred media for fast exchange of information, especially scientific information, and of course, blogging. But the convenience of reading a printed book or magazine, especially popular science, any time at any place is a big advantage with print media that the electronic media may not be able to provide. The growing number of popular science titles being printed worldwide every year and their expanding readership point to the popularity of the print media despite the global spread of the electronic media. It may be a question of getting used to a new media, but reading a book or magazine in print form still remains more comfortable and convenient than reading a magazine or book on a laptop, iPad or e-reader. Further, reading a printed book or magazine can never be interrupted by a low or run-down battery!

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Towards The Next Generation Multimedia Presentation

Ranjan Parekh

Abstract

Conventional multimedia productions display a sequence of frames to the user in a linear or non-linear way depending on user interactions. Each frame consists of a fixed set of information through the incorporation of media elements embedded within the frames. Such a traditional framework however fail to meet many of the modern day requirements like need for frequent content updation, customizing the presentation according to user requirements, transmitting the presentation over lowbandwidth networks and supporting distributed media components. This paper has been inspired by the lack of tools to solve all of these challenging problems. It aims at introducing a new framework in structuring multimedia presentations by moving the focus from the concept of frames to the concept of objects. By representing a multimedia presentation as a set of meaningful objects, each associated with its own spatio-temporal parameters, it becomes possible to customize presentations as per specific user needs and introduce functionalities like content searching, which can benefit application areas like distance learning. The paper also discusses issues related to playback of such a presentation over a distributed environment. Moreover it is seen that such frameworks can be made to support and utilize emerging standards like MPEG-4, MPEG-7 and MPEG-21.

Key words

Content-based multimedia retrieval, Multimedia database, Semantic content searching, Scripting representation.

1. Introduction

Over the last decade there has been a huge proliferation on the use of multimedia content throughout the world. Application areas like digital photo albums, computer based training and learning packages, games and children entertainment, online business and corporate presentations, information kiosks and simulation packages have led to the growth of a large number of varied presentations. Traditionally these presentations are created by embedding a fixed set of media elements within a presentation template, specifying their spatial and temporal attributes, building interactive pathways for nonlinear navigation and compiling the entire collection as executable files with their own run-time engines. Authoring tools like Director, Toolbook, Authorware etc. have been used for such purposes. In recent times however people have begun to look at other fields as possible application areas of multimedia technology. These areas are quite different in various aspects from their traditional counterparts and present new design and implementation challenges to the developers, which are extremely difficult and inconvenient to be handled using existing methodologies. Rather they require a paradigm shift of current practices and call for some new concepts to be incorporated for adequate solutions.

2. Problem Analysis

One such situation occurs where media components need to be *frequently changed* or updated, possibly to reflect the changes in a physical entity over which it is modeled, for example a digital art gallery. In a real world gallery new specimens might be added to the gallery every day or older specimens taken out. Even for existing artwork, specimens might be grouped into different categories based on subject matter or chronology, descriptive text captions could be changed to accommodate new information or newer links between related artworks could be created. To reflect the same changes in the presentation, structure of the original presentation would need to be modified on a periodic basis. Since an executable file precludes any change to its internal structure, the development work would continuously involve changing source codes, recompiling the entire presentation and its distribution to the audience periodically. This involvement of time and effort as well as the inconvenience of repeated distribution would make the system economically and practically infeasible. Failure to do so would make the digital version hopelessly outdated with respect to the real-world entity.

Another situation arises from the fact that the user requirements may be *too large or varied* to be envisaged and implemented adequately in a single fixed presentation. Let us consider a scenario where a multimedia presentation is being used to model a digital museum. Traditionally a menu structure is used to navigate to different sections of a presentation as determined by the author. However choices in the menu should also reflect the preferences of different users for navigating through the presentation. For example one user might want to view rock samples from a specific geological era, while another might want to view rock samples found in a specified geographical region, while a third might want to view rock samples containing a particular ore of iron. It could easily be appreciated that the large number of potential choices could hardly be satisfied using rigid hyperlinks. Moreover it is entirely possible that the same page may be part of the result set of all the above three queries. Existing authoring tools do not support creation of dynamic links to reflect varying user choices. Such variety would also be present in other related scenarios like presentations linked to a digital audio library where users can ask for playback of a certain composition by specifying artists, music types, chronological period etc., or a video-on-demand systems where users might have a wide number of choices pertaining to actors/actresses, director, music director, chronological period, genre, awards etc.

Computer systems nowadays are rarely stand-alone and usually linked to local or global networks. Traditionally multimedia presentations have been developed for playback on a single computer. They may exhibit inconsistent behaviours when accessed by multiple users from different hosts on the network. To cater to modern computing needs and utilize the advantages of networking, the architecture of multimedia presentations would need to be modified so that they can *function in multi-user environments* with different users browsing different pages and activating different links simultaneously from different geographical locations. The issue of where the presentation itself should reside is also important from the viewpoint of optimum efficiency and performance. Media components embedded within a presentation increases its *byte size* to the order of hundreds of megabytes. If the presentation is to work in a networked environment, byte size becomes a crucial factor, especially for bandwidth sensitive networks. In some situations the presentation may need to be populated with *distributed media components* e.g. teachers and experts may create content for e-learning packages from geographically disbursed locations. In such scenarios, issues which need to be considered are, on one hand, how the presentation would maintain its structural integrity, and on the other, how the spatio-temporal properties of media components remain intact as they are fetched over networks with potentially varying transmission speeds and delays.

3. Requirement Analysis

In this section we attempt to build up a set of requirement factors that would adequately address the problems discussed in the previous section.

3.1 Traditional view of multimedia presentations

Traditionally a multimedia presentation is viewed as a single executable file containing its own run-time engine, and within which all the media components are embedded. Each of the components are associated with a set of spatio-temporal parameters which determine how and when it appears within the presentation. A set of event handlers are present for accepting user and system initiated events and allowing the user to navigate in a nonlinear fashion. A *multimedia presentation MMP* is therefore represented as a 4-tuple $MMP = \{M, P, E, R\}$, as shown in Fig. 1, where M denotes the set of all media elements, P the set of spatio-temporal parameters, E the set of event handlers and R the run-time commands, also called run-time engine, which is contained within and inseparable from the presentation.

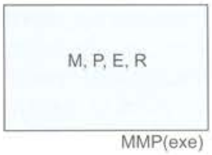

Fig.1 : Traditional view of multimedia presentation.

3.2 Separation of media

In order to support frequently updated media components and also to enable them to be searched for, based on user defined criteria, the first modification which needs to be done to the traditional structure is the separation of the media components from the rest of the presentation. This situation is depicted in Fig. 2. The set of media components M is now separated from the multimedia presentation MMP, and stored in an external *media repository MRP*. For the time being let us consider MRP to be resident in the same local machine where MMP is executed and ignore the delay associated with data flow between them. The set of media elements M is referred to from MMP via a set of locational parameters, typically pathnames, indicated by the symbolic link $L1$. Data actually flows from MRP to MMP during playback via physical link $L2$. A distinct advantage of this scenario is the reduction of the size of MMP due to the separation of M into MRP. This translates into a lower startup delay during the execution of MMP, as media elements are pulled into MMP as and when they are required, instead of loading into memory all at the same time. Another major advantage is that it would enable developers to change content without modifying the presentation and would be especially helpful for applications requiring frequent updation of media content. New content material could just be loaded into the *MRP* when required, overwriting the old content, and the next time the presentation runs, it would automatically reflect the latest updates. A third benefit would be the ability to enable structural modifications of *MRP* independent of *MMP*.

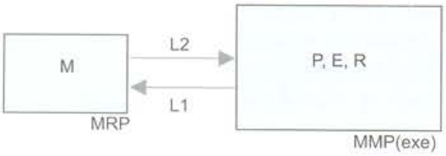

Fig. 2 : Separation of media.

3.3 Separation of run-time engine

P and *E* reflect the variations how various media components appear and disappear within the presentation, and expressed as a set of instructions, typically using some internal language supported by the application software which has been used for creating *MMP* e.g. Lingo for Macromedia Director[1]. These instructions are then interpreted by the run-time engine *R*, which also accepts the media components from *MRP* and finally play them back. *R* represents a fixed command set, which take as input the set of media components and the instructions, and produce as output the final presentation. Thus *R* may be separated from *MMP* into an external component called *playback module PBM* as shown in Fig. 3. *MMP* remains connected to *MRP* through link *L1* and to *PBM* via link *L3* for transmitting *P* and *E*. The media components now actually flow to *PBM* via link *L2* where they get displayed. *PBM* would be a fixed module for a particular class of presentation and could stay resident on the target machine from beforehand, thereby avoiding the overhead of transporting it along with *MMP*. This would be more crucial when network environments are considered. The separation would also mean that *PBM* could be optimized for efficiency independent of *MMP*.

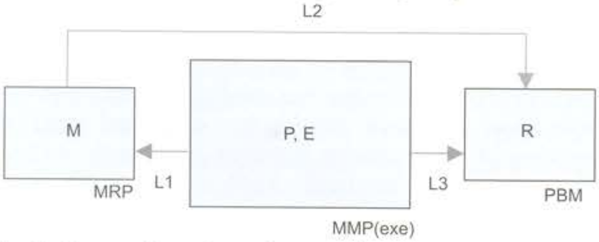

Fig. 3 : Separation of run-time engine.

3.4 Scripting Representation

MMP has till now been considered as an executable file which needs to be compiled for playback. With the separation of the run-time module, *MMP* is left with *P* and *E*, both of which can be expressed as instruction sets.

In order to address the problem of frequent and quick modifications of multimedia presentations, it is proposed that *MMP* be represented using a scripting language instead of an executable file. The script representation would preserve the compact size of the presentation and would enable the developer to make frequent updating of the design and layout, without the need to go through a time-consuming recompilation phase every time. This would help to reduce development and content creation time. Also a script file being essentially textual in nature, could be edited easily using text editors, thereby avoiding the need for specialized software. This might be beneficial from the economic viewpoint. The *PBM* in this case would need to function as an interpreter of the script in the *MMP* and would contain interpreter functions *I* in addition to *R*. This is depicted in Fig.4. A typical example of such a script language would be SMIL by W3C[7].

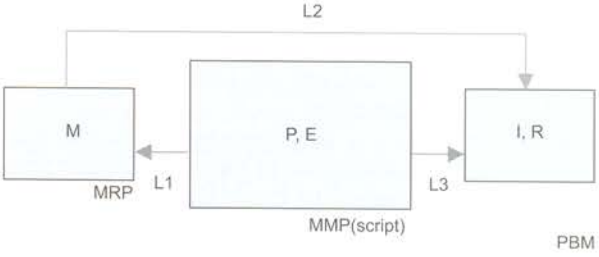

Fig. 4 : Scripting representation.

3.5 Media Searching and Retrieval

Till now a fixed set of instructions within the *MMP* locate the actual media components *M* within *MRP* and cause them to be played by the *PBM*. This leads to a static structure essentially decided by the developer. We have however seen above that a dynamic presentation structure is desirable, where users can themselves search for and retrieve media components according to their customized needs. The first step for this important functionality was already achieved when media components were separated from the presentation and therefore retain their individual entities within the *MRP*. This advantage could be exploited to enable the users to search for and retrieve specific elements from the *MRP* and dynamically insert them within *MMP*. We propose the inclusion of a *multimedia database MDB* into the architecture to handle the queries generated by the user (Fig. 5). We discuss the structure of the *MDB* in section 4 later, for the time being we assume, features of media files kept in the *MRP* are extracted by an extraction function *X* and kept in the *MDB*. These feature information serve to characterize the media components and flow from the *MRP* to the *MDB* via link *L5*. The features however remain linked to the actual files through symbolic references *L1*. Queries can be posted using query interface functions *Q* in the *PBM* and are transmitted via link *L4* to the MDB, where they are interpreted and a result list is generated by a searching function *S*. *Q* can serve as a parser to check the validity of the query syntax. The result list would typically be references to a subset of media elements in the *MRP*, which match the user-specified criteria in the query. The symbolic references between the result list in the *MDB* and *M* is indicated by same link *L1*. The result list is displayed back to the *PBM* using link *L4*, using which the user can further modify the result list by picking one or more specific items from it or generating additional queries. After the final modification of the result list, the selected item names are passed to the *MMP* via link *L6*. *MMP* does not contain the actual names of the media elements, but only place-holders which gets subsequently filled up from the *MDB* via *L6*. At the same time, the actual media items referenced are sent from the *MRP* to the *PBM* via link *L2* to be displayed/played within the presentation. To actually play those elements the *PBM* would also need the *P* and *E* information from the *MMP*, using link *L3*.

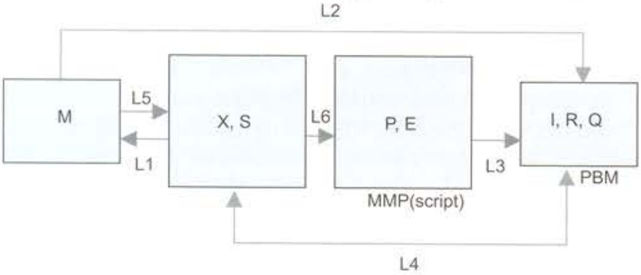

Fig. 5 : Media searching and retrieval.

3.6 *Distributed media*

Until now we have been assuming that the media components are resident on a local system. In a general scenario these components might be distributed over an accessible network including the Internet. Referencing the files from the *MDB* could be done through fully qualified domain names (FQDN). Population of the database is done off-line so network delays would not be crucial during this phase. However during playback of the presentation, network delays can assume important proportions as the media files flow from the now distributed *MRP* to the *PBM*. This can increase the skew to a large extent so that synchronization constraints may need to be imposed. The playback issues are discussed in detail in section 5.

4. *Storage and Retrieval*

The inclusion of an *MDB* means that the database needs to be populated before it can be utilized. This is typically done off-line by a supervisory system before it can handle on-line user queries. A multimedia database can be defined as a data structure which enables searching and retrieval of textual as well as non-textual media like image, audio and video. Traditionally relational databases have functioned by using pattern matching algorithms in textual strings to find query results. A media component like image or audio essentially consists of raw data bytes with very little inherent meaning or useful information within it, which may be used for query matching.

4.1 *Textual annotations*

The earliest approaches to media searching therefore relied on textual annotations manually generated by individuals and attached to the media component, thereby trying to adapt existing methodologies to a new application. However major drawbacks of this approach were soon apparent. First, the subjective nature of the manual descriptions precluded its universal application to media searching: the same object could be referred to using different textual terms, while in other cases the same term was used to refer to different objects. Secondly because of human intervention the process required huge effort and time involvements, which were not practicable for large databases. Thirdly, it could be used only when textual descriptions of the item were available, which was not always the case.

4.2 *Low-level features*

To overcome these limitations feature extraction algorithms were developed which could extract low level features from media components in an unsupervised or semi-supervised manner. Apart from the fact that these required minimal human intervention and so were much faster than manual methods, they also overcame the limitations of subjective manual descriptions and so were much more reliable. They also overcame the limitation that queries need to be expressed in textual terms. A query could now in principle be another media element from which low-level features could be extracted and then compared with similar features previously extracted from media components kept in the database. The result list could then be generated based on the similarity between the query media features and database media features. These techniques were not without their own problems. Firstly the features extracted could not generally be expressed as text strings but required multi-dimensional mathematical vectors to be represented. Existing database structures could not efficiently handle such vectors and newer database architectures were required to be developed. In general it was felt that object oriented databases were more efficient in handling such data structures than relational databases. Secondly, relational techniques were based on exact matching of text strings, but non-textual media did not usual require exact matches. The concept of "similarity" was needed to be defined using which even a partial match between media components would quality as they being regarded as similar. The concept of similarity was however mostly founded on human perceptions and it was difficult to quantify it. Also the fact there were large variations as to the extent of similarity between individuals complicated matters further. Thirdly, computing each and every feature required large resources and were usually not feasible in practice. Methods as to how the entire information could be represented using smaller and compact data sets became crucial.

A wide plethora of algorithms have been developed to handle feature extraction. For images one of the most widely used features is color, either as individual pixel values[2] or as histogram plots[3] computed over partitions in the image[4, 5, 6]. An alternative approach called color-signature is used to represent color as a string of bits instead of a histogram[7]. Another approach is to isolate clusters of colors from images and using the amount of overlap between them to compute similarity[8, 9]. Because the RGB color space is not perceptually uniform, use of a proper color space and color quantization scheme have been emphasized in all color based retrieval systems. In most CBR systems, the HIS (or its variant HSV) color space is used to represent and compare color values in images because of its perceptual similarity with the human visual system and also because of its invertible transformation relations with the RGB space[10,11,12,13,8]. Other than color, shape information has also been used to capture low-level features. Shapes of objects in an image have been mapped into a grid of cells and a string of bits are used to represent them by assigning 1 to cells covered by the shape and 0 to other cells[14]. The turning angles method[15] uses the angles of counter-clockwise tangents to describe the boundary of a shape. The centroid-radii approach[16] uses the lengths of a number of radii drawn from the centroid to the periphery of the shape at equal angle separations, to describe the shape. Texture is another feature which has been used to compare images. Textures are distinguished as irradiance patterns containing a limited range of spatial frequencies and orientations usually identified by Gabor filters[17, 18, 19].

For audio the first step is to categorize them into either speech or music. The features that can be used for discriminating them include average energy, silence ratio, zero crossing rate in time domain and pitch and spectral centroid in frequency domain[20]. Each of these features may be used individually in different classification steps[21,22] or a set of features can be used together as a vector[23,24]. One approach to speech recognition is to compare waveform patterns corresponding to phonemes, the smallest unit of pronunciation, with segments within audio clip[20] in order to identify words spoken. Music can either be sample-based e.g. WAV files or structured e.g. MIDI files. There are two general approaches to comparing sample-based music. In the first approach a set of features are extracted from the audio clip and represented as a vector, which is then used for comparisons. These features may vary over time and would need to be computed for each frame. In[25] five features namely loudness, pitch, brightness, bandwidth and harmonicity have been used with each feature being represented statistically by three parameters : mean, variance and autocorrelation. In the second approach pitch of each note is extracted, and represented as a string of symbols. The retrieval decision is based on the similarity between query and candidate strings[26, 27]. In structured music the notes are already present within the file as a set of instructions. These instruction sets are used to compare MIDI sequences for similarity[28]. The MPEG-4 Structured Audio is a new standard in this direction which represents sound using algorithms and control languages[29].

For video the feature extraction process involves the identification of individual frames. Frames are then grouped into a shot, which represent a continuous action in time and space or camera motion and therefore contain similar low-level features. One promising approach to shot detection is to identify abrupt scene cuts as well as gradual transitions. Most of the approaches working on uncompressed video use frame difference as a measure for shot boundary detection. Frame differences are usually derived by partitioning and computing local histograms[30,31]. To reduce computational loads frame sizes can be reduced to iconic sizes e.g. 16×16 pixels[32]. Gradual transitions are detected by using a moving query window on either side of a current frame and computing the ratio of differences between pre-frames and post-frames[33]. Approaches working with compressed video use one or more features of the encoding algorithm such as DCT coefficients, macro-blocks and motion vectors[34,35]. Once the shots are identified the next task is to group semantically similar shots into scenes. The methodology followed by a majority of researchers is to identify certain keyframes within each shot, also called representative frames or r-frames[32] that best depict the content of that shot and then compare r-frames of different shots to gauge similarity between them. Each r-frame is represented by a set of static and dynamic features for comparisons. Static descriptors include typical image features like color, texture and shape[4,36,37]. Dynamic features are a based on motion descriptors derived from optical flow analysis[38, 39]. The calculations are based on brightness constraint equations proposed by Horn and Schunck[40] which express the fact that under constant scene illumination the brightness of the same physical point should remain constant despite camera motion.

4.3 Identifying semantic objects

In the context of CBR systems humans tend to pose queries using the semantic nature of media contents. Systems based on low-level features would not be very effective in those situations because of the gap between how the media content is interpreted by the humans and the machines. To be truly effective a CBR system would need to understand the semantic nature of media content and tune its retrieval engines according to the interpretation of these features. A *semantic object* (SO) is a collection of image pixels or audio samples that corresponds to the projection of a real object or event in an image, audio or video sequence e.g. a cluster of trees, a car moving along a road, a laugh or scream. To extract such objects automatically a clear characterization of such objects is required. Unfortunately since semantic objects are human abstractions, a unique definition does not exist. In addition, since semantic objects cannot generally be characterized by simple homogeneity criteria (e.g. uniform color or uniform motion), their extraction is in general extremely difficult and only in recent times this problem is being addressed by researchers. One approach is to use high-level descriptions instead of low-level features in the matching process. How to extract highlevel descriptions from media elements and to fill the gap between low-level features and human's understanding of the media contents, is a critical issue. One promising technique to solve this problem is to describe the media content with a hierarchical structure to reach progressive content analysis[41,42,43]. The contents of the media can be represented in different levels[44] such as the 3- level representation of[43]: feature level, object level, scene level, or 5-level representation of[42] To fill the semantic gap, one makes the system extract low-level features while the user puts more high level knowledge and the system tries to integrate the two to arrive at a more complete description[45]. Among related majority of researchers is to identify certain keyframes within each shot, also called representative frames or r-frames[32] that best depict the content of that shot and then compare r-frames of different shots to gauge techniques relevance feedback has been paid a lot of attention because it can combine the information from the user with the automatically extracted features. Many methods have been proposed to reach the goal of relevance feedback[46,47,48]. According to the amount of human intervention required we can classify the process as manual, semi-automatic (supervised) and automatic (unsupervised). In case of manual extraction the rules for extraction of semantic video objects are directly applied by the user. The method enables high accuracies in identifying spatial and temporal boundaries but is very time consuming especially for large video databases. A *manual* extraction procedure may be followed in some cases requiring a high quality production or to benchmark automatic or semiautomatic techniques[49]. *Fully automatic* extraction procedures are still in their infancy because translating properties of SOs into extraction criteria is difficult. For this reason many semi-automatic extraction procedures have been proposed as a trade-off between fully automatic and manual extraction strategy. The procedure involves the interaction of the user during some stage of the extraction process. Usually the user provides initial information about video segmentation after which a tracking mechanism follows its temporal evolution in the subsequent frames. The object boundaries may need to be modified and updated either via further interaction[50] or according to some low-level homogeneity criteria[51]. Fully automatic extraction methods apply the rules of defining semantic objects in an algorithmic way. These rules are based on special characteristics of the scene or on specific knowledge (a *priori* information). They are derived for a specific class of applications. An example of such applications is chroma-keying, employing a background of known color (usually blue or green) and extracting objects by discarding background pixels. In other approaches, some knowledge of the objects to be extracted are utilized. An example is a face detection algorithm, which makes use of the shape and location of various facial features to extract information[52, 53]. In other cases motion information can be used to extract moving objects from a scene. Motion estimation aims at characterizing apparent motion by a displacement vector or an optical flow field. A displacement vector describes the displacement of a pixel in two frames of the video. The optical flow is the distribution of the apparent velocities that can be associated with the apparent motion. Estimating motion is a difficult task as it is highly sensitive to noises and variation in scene illumination. Another problem in motion estimation is referred to as the occlusion problem. This stems from the fact that the object in question may be occluded by other objects in some of the frames thereby producing a gap in its motion vectors over a period of time. To cover the gap assumptions are needed which are usually smoothness constraints on the optical flow field to achieve continuity. Reviews of the different techniques are proposed in[54] and comparative tests for performance evaluation are reported in[55].

4.4 Similarity Metrics

Unlike traditional databases, most of the queries in multimedia databases are based on similarity. For example, "Find all images that are similar to a given image, within a user-specified range" or "Given an image, find the five most similar images". The similarity search problem therefore becomes a nearest neighbour search problem in the feature space. According to the elements considered, distance measures may be classified as point to point, set-to-set and point-to-set. A *point-to-point* distance vector computes the proximity between two feature vectors. Let $S=(s_1,s_2,\ldots,s_n)$ and $T=(t_1,t_2,\ldots,t_n)$ be two feature vectors in n dimensional feature space. Then the difference *diff (S,T)* between S and T using an L_p metric is as follows:

$$diff(S,T)=\left[\sum_{i=1}^{n}|s_i - t_i|^p\right]^{1/p}$$

where p is the order of the metric. For $p=1$ it becomes the Manhattan distance,

$$diff(S,T)=\sum_{i=1}^{n}|s_i - t_i|$$

while for $p=2$ it becomes the Euclidean distance.

$$diff(S,T)=\sqrt{\sum_{i=1}^{n}(s_i - t_i)^2}$$

For $p\rightarrow\infty$ the distance is defined by :

$$diff(S,T)=\max_{1\leq i\leq n}|s_i - t_i|$$

A *set-to-set* distance computes proximities of two sets C_i and C_j for which several strategies may be adopted. For example it may be computed as a function of the point to point distances of the points belonging to the two sets. The minimum, the maximum or the average distance may then be chosen. The computational complexity of this method is high and increases with the cardinality of the sets. A simpler solution is to choose a representative of each set and then to compute the *point-to-point* distances between them. To account for the cardinality of the sets, a normalization procedure may be introduced. A *point-to-set* distance computes the proximity between a feature point S and a set C. An example is considering the point to point distance from S from all the elements in C and then considering the minimum, maximum or average. Such a method is again computationally heavy if the cardinality of C is high. A simpler solution is to take a representative value of C and then to compute the distances. Point-to-set distances are typically used in region growing techniques.

4.5 Indexing Mechanisms

A similarity metric enables us to compute similarity between vectors using distance as a measure. However since multimedia data is potentially computation intensive efficient calculations require indexing mechanisms. If the *MDB* has a small size of the order of hundreds of objects a sequential scan of the entire database may be adequate. However as the database size grows the sequential scan is not a reasonable arrangement, especially if similarity computations are non-trivial. What is needed is a way to filter out objects that are non-relevant to the query without dismissing relevant objects. In the previous section we saw that our concept of similarity can be modeled by means of a distance function in a suitable metric space. In order to deal with such queries an access method should implement a clustering method, for grouping together similar objects, and a way to represent such clusters for indexing purposes. This means that classical tabular structures like B-trees are not suitable. To support spatial search operations multi-dimensional or *spatial access methods* (SAM) are required. In recent times a plethora of such methods have been proposed[56,57]. The search operations that concerns us most are those of range and nearest neighbour queries. A range query defines a region of the space centered on the query value and whose shape depends on the used metric. The R-tree[58] is a multi-dimensional generalization of the B-tree and may be used to store rectangular regions of an image[59,4]. Because disk accesses are often slow, R-trees provide a convenient way of minimizing the number of disk accesses. Each R-tree has an associated order which is an integer K. Each non-leaf R-tree node contains a set of at most K rectangles and at least K/2 rectangles. This feature makes R-trees appropriate for disk based retrieval because each disk access brings back a page containing several i.e. at least K/2, rectangles. One drawback of the R-tree stems from the fact that since node regions may overlap even an exact match point query may lead to multiple search paths. Variants of the R-tree have been proposed to improve searching efficiency. These include the R+-tree[60], R*-tree[61], HR-tree[62] and X-tree[63]. For storing higher dimensional point data, KD-tree has been proposed[64,65]. Here each node represents a point in a k-dimensional space and is associated with an array of length k. The answer to a range query is the set of all points within a specified distance of the query point.

4.6 Semantic Interpretation

Extraction and representation of low-level features and semantic objects is not sufficient to appropriately handle user queries because the system still cannot interpret what the features or objects mean. Humans are most likely to post queries mentioning semantic concepts like people, trees, road, car and events like running, laughing, explosion etc. The gap between recognizing a pattern of features and knowing what it means is to be bridged by feeding knowledge to the system. Based on this knowledge, the system should not only be able to interpret the meaning of the objects but also to learn and deduce about related matters. We propose the inclusion of a knowledgebase into the architecture to accomplish these tasks. Only in very recent times researchers have begun looking into the task of automatic semantic interpretation. In[66] the authors have used Bayesian networks to characterize multimedia semantic features into three categories : objects (man, car), sites (indoor, beach) and events (walking, explosion), collectively called multijects. To make the system learn and infer, it is pointed out that detection of certain multijects may boost or reduce the chances of detecting certain other multijects. For example the detection of "sky" and "water" boosts the chances of "beach" and reduces the chances of detecting "indoors". An important observation from this interaction is that it might be possible to infer some concepts, whose detection may be difficult, based on their interaction with other concepts whose detection may be relatively easier. In[67] the authors propose a model for predicting words associated with whole images and specific image regions. In[68] the authors propose a way to discover and measure statistical relationships among concepts from images and corresponding text annotations. To estimate spoken words and identify the speaker in an audio clip Hidden Markov Models (HMM) are the most widely used and produce the best performance[69]. Recent contributions in statistical learning have provided new learning methods. Taskar et al.[70] proposes a new framework – the Maximum Margin Markov Network (M^3N) which integrates kernel methods, which maximize the margin of confidence of the classifier, with graphical methods, which can exploit the complex structure of multimedia.

4.7 Database Model

From the discussions of the previous sections we can now arrive at a model of the multimedia database.

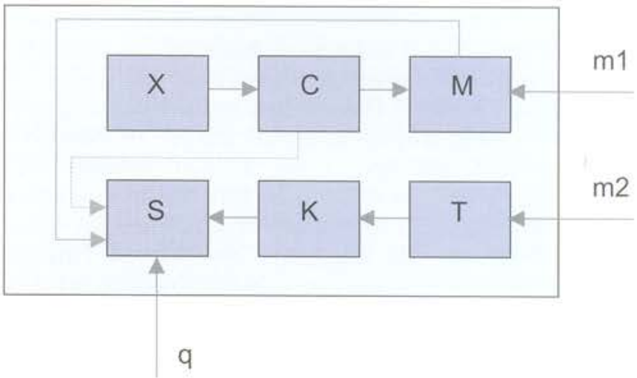

Fig. 6 : Functional blocks of the database.

The feature extraction block X is primarily concerned with the extraction of low-level features from the media components kept at the *MRP*. It would comprise of a set of algorithms which would read the raw binary data of media files and extract a set of pre-defined features e.g. pixel values from image files, sample values from audio files. The algorithms would be different for different media types, even for the same type the algorithms would vary depending on which feature needs to be extracted. In general it could be represented as a combination of different extraction functions with weights:

$$X = w_1X_1 + w_2X_2 + w_3X_3 + \dots$$

where X_1, X_2, X_3,...are the functions for extraction of specific features and w_1, w_2, w_3,...are their respective weights which determine their importance or influence in the process. In general these features would not be utilized in their native form but would need to be converted into another form for effective storage and retrieval processes. There are two main reasons for such conversion. First, considering all these features might not be feasible as their numbers could be very large e.g. an image 1000 × 1000 pixels gives rise to three million (R, G, B) values, a CD quality audio contains 44100 samples every second. A conversion algorithm would therefore need to transform the original feature values into a more compact representation. An example would be to segmentan image into a number of partitions and compute a brightness histogram for each partition. The second reason for the conversion is that the form in which the features are extracted may not be suitable or efficient for subsequent processing. For example pixel values in an image are usually extracted as RGB triplets, but the

RGB color space not being perceptually uniform, uniform quantization of the color space leads to redundant bins and holes in smooth color variation. Hence conversions to HSB or CIE-Lab color spaces are recommended. The function *C* represents all these types of conversions which might be necessary. Typically the output from this stage would a set of multi-dimensional feature vectors that can be mapped into a feature space before being compared. The next step is the identification of semantic objects and is done by function *M*. Here algorithms attempt to interpret low-level features to derive meaningful entities from them in manual, semi-automatic or automatic ways. Fully automatic processes require *a priori* information which could be inherent within function *M* e.g. known color of a scene background. Manual and semi-automatic processes would require additional semantic information, represented here by *m1*, which would need to be inserted in a supervised fashion e.g. a contour of an object in a scene. The next step is the function *T* where the features are stored using an appropriate index mechanism e.g. Rtree or KD-tree. This would be required for efficient search and retrieval functions. Although low-level content form the major portion of the indexed data, in some cases high-level semantic content may also need to be inserted, represented by *m2*. This step would be optional and require intervention by a human content expert. Typically such information would be represented by text strings. An example would be the insertion of name and date of birth of a person in a photograph. Such intervention would however typically be in very small amounts. After all the low-level features and semantic objects have been extracted the final step would be to interpret their identities. For this a knowledgebase *K* is inserted within the database which would typically attempt to match the information kept in *T* with previous information within it inserted during a training phase, and infer about presence of real-world entities within the media objects. The output from *K* would typically be text strings (labels) describing the interpreted object along with their locational information within a scene e.g. a tree to the left of a road. Since each of these different levels of interpretations have been derived from *X*, they inherit the symbolic link to the corresponding media file kept in the *MRP*. The searching function *S* would attempt to find a set of media components which satisfy criteria in query *q* by considering both low-level and semantic information.

4.8 Proposed Layered Architecture

To process information at various levels this paper proposes a layered architecture for content based retrieval functions. Each layer processes media information at a specific level and hands over the results to the next higher layer for a progressive understanding of the media content. The bottom-most layer is the Physical Layer which deals with issues for representing the raw data of the original media component. To illustrate the model we consider a video clip since it is the most complex media type and embodies other media types like image and audio within it. A video segment can be represented as $f(x,y,t)$ in this layer, where the visual and audio content is considered a function of two locational coordinates x and y, and time t.

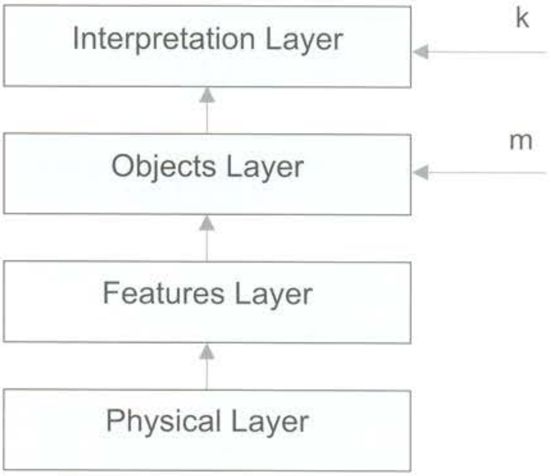

Fig. 7 : Layered architecture of the CBR engine.

The next layer is the Features Layer which deals with the functions for representing the features in an appropriate feature space for effective clustering. This results in the generation of the video segment $g(x, y, t)$ from the original representation due to a transformation F.

$$g(x,y,t)=F\{f(x,y,t)\}$$

An example of such conversion is the transformation of pixel data from the RGB into the HSV color space[10,11,12] using equations proposed in[74]. This layer also deals with extraction of low-level features which leads to the decomposition of the media into a collection of homogeneous regions R_i corresponding to perceptually uniform areas. The process is known as region segmentation,

$$g(x,y,t)=\bigcup_{i=1}^{N_R} R_i$$

where N_R is the number of regions in the video. Also these regions in a specific frame n do not overlap. Hence

$$R_i(n)\cap R_j(n)=0,\ \text{if } i\neq j$$

The third layer called the Object Layer would deal with the identification and representation of semantic objects, a process known as semantic segmentation. The semantic partitions are defined through human abstractions, consequently the definition of the partition depends on the tasks to be performed. In general the partition cannot be expressed through homogeneity criteria e.g. same color, because the elements of such a partition do not possess invariant properties. Additional semantic information m can optionally be added to this layer through human intervention to improve identification of objects. The output of this layer would be in the form of a collection of semantic partitions or objects S_j:

$$g(x,y,t)=\bigcup_{j=1}^{N_s} S_j$$

where N_s is the total number of semantic objects in the video. Also these semantic objects in a specific frame n do not overlap. Hence

$$S_i(n)\cap S_j(n)=0, \text{ if } i\neq j$$

A generic semantic object can be considered to be divided into a number of regions such that

$$S_i = \bigcup_{j=1}^{N_R^S} R_{i,j}$$

where $R_{i,j}$, represents j regions of the i-th object, and N_R^S is the number of regions in a semantic object. The situation is depicted in the figure below. These SOs can be identified if for example the background is of a known color, which is not present in any of the objects, and noting that two objects cannot overlap.

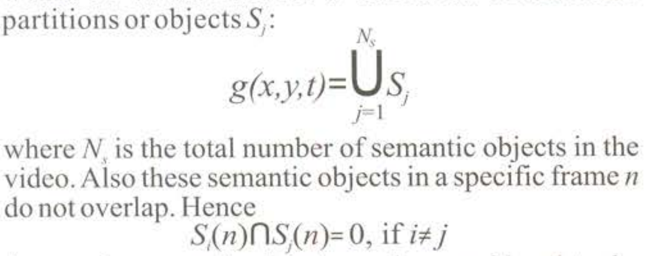

Fig. 8 : Identifying objects and regions.

It is to be noted that the concept of SOs is not restricted to visual objects only, it can be applied to audio as well. SOs in an audio clip can be a person speaking, a train leaving a station, a musical composition while regions can comprise of short sounds having an overall homogeneous characteristic like a laugh, scream, gunshot, whistle, breaking glass or a single stroke of a violin.

The topmost layer, called the Interpretation Layer would include a semantic knowledgebase for proper interpretation of all the information. Typically it would accept information about SOs from the Objects Layer and some additional information k from a previously trained knowledgebase. It would then attempt to match characteristics in order to derive an interpretation about the SO. Usually the interpretation engine would be based on a probabilistic framework like a Hidden Markov Model (HMM). First an HMM would be trained based on the feature vectors of a specific media type, which would constitute the knowledgebase. This involves attaching semantic labels to a time sequence of low level features e.g. man walking, bird flying, indoor, outdoor, sunrise etc. The training set is labeled independently for audio and video components using the HTK Toolkit. The Viterbi algorithm is then used to find the best possible state sequence given the trained HMMs and the feature vectors.

The optimal state sequences found by the Viterbi algorithm in the video and audio are then used as inputs to a supervisor HMM, which fuses the modalities. Its observations are the states of the media HMMs. Since the observation rate of the video and audio are not the same, the state of the media HMMs are sampled at a fixed rate to produce the observation sequence for the supervisor HMM. The supervisor HMM is then trained after which it along with the media HMMs emit the probability of the occurrence of a media object. The effectiveness of such a model is reported in[66].

5. *Playback and Synchronization*

The presentation is played back on the *PBM* by retrieving actual media content from the *MRP* and the spatiotemporal parameters and event handlers, together referred to as authoring parameters, from the *MMP*. Important issues which need to be considered here are the delay factor, jitter and skews for effective synchronization of parallel media streams. Two or more media files retrieved separately from the *MRP* may need to be played together e.g. an audio and video, or a sequence of images along with textual descriptions. The delay factor usually refers to the time taken for the objects to travel from the source to the destination, but for interactive applications it also includes the time for the user interaction to travel from the destination to the source. Due to variations in delay factors, temporal relationships between media components can deviate from their desired values. This is referred to as jitter and quantitatively refers to the instantaneous difference between the desired presentation times and actual presentation times. Skew is the average jitter value over a period of time. The major requirements for audio/video synchronization in multimedia systems are bounded jitters within a continuous stream, and minimal and acceptable skews among dependent streams. Steinmetz's experiments[75] showed that for audio/video synchronization skews less than 80 ms are ideal, between 80 and 160 ms are acceptable and beyond 160 ms are considered annoying. If the *MRP* is resident in the same local system where the presentation is played back we can ignore the skew produced in traveling from the *MRP* to *PBM* and assume that they are available at the *PBM* instantaneously. Synchronization could then be imposed by the *MMP* script in two ways. The first way is by ensuring that the data elements begin playback at the same instant within the presentation and assume that they would be able to maintain synchronization after that. This is suitable for situations where synchronization requirements are not very rigid i.e. relatively large skews may be allowable. This restriction can be implemented by the script e.g. the <PAR> and <SEQ> commands of SMIL[71] for parallel and sequential playback. The second way is by placing pre-defined markers in the media files and then imposing the playback head to cross the corresponding markers in different files at the same point in time. In this case the markers could be placed by the developer in the *MRP* and the *MMP* script should be able to recognize them. If a set of media components needs to play together in parallel maintaining synchronization, as the playback proceeds to the first marker of one of the files, the script should be able to pause the playback of this file until the playback of other files proceeds to their corresponding first markers; then the playback of all files again proceeds together. In a way the second method can be considered as a repetitive application of the first method over a number of points within each file. This method is suitable for situations where synchronization requirements are strict i.e. where large skews are not allowed. An example is the recognition of cue points by Lingo[1].

In a distributed network environment the *MRP* and *PB* would be located on different systems. Maintaining synchronization in such cases is more complex than in local environments due to the distributed storage of synchronization information and different locations of media objects. There are two approaches : (1) best effort environment with adaptive protocols (2) reservation based environment. In the first case networks and OS maximize the throughput and do not provide QoS guarantees e.g. Internet network with UNIX OS support at end-points. Adaptive transmission protocols like VDP[76], vat[77] and RTP/IP are deployed on top of this environment. In the second case the network and OS use reservation, admission and enforcement algorithms to provide end to end QoS guarantees e.g. ATM network with QoS-aware resource management in the OS kernel. Examples of protocols in this type of system include the native ATM transport protocol in QualMan[78] and RSVP/IP. A number of different techniques have been proposed for multimedia synchronization to satisfy diverse requirements, which implement synchronization control at various locations at the source and destination. In[79] the authors suggest two different schemes for inter-stream synchronization, the synchronization marker for indication of synchronization points and the synchronization channel over which the markers are transmitted. Escobar's scheme[80] takes into account the dynamic changes in network delays by monitoring the jitter and re-synchronizing at the receiver if necessary. However it assumes the presence of a global clock in a distributed environment at all times. Similar approach is taken in Rothemel's scheme[81]. Another approach is to send feedbacks like Ramanathan's scheme[82]. The playback devices provide feedback messages to the server based on which the server can estimate the earliest and latest times by which playback needs to be initiated. In order to determine temporal relationships between streams relative time stamps are assigned to each media unit. Rangan[83] discusses the continuity and synchronization issues in MPEG compressed video streams. The choice of the actual scheme depends on the system requirements and limitations. According to Nahrstedt's studies[84] the adaptive synchronization has a low demand on underlying resource managements, the call establishment phase is simple and fast, however this protocol needs to work very hard during the transmission phase in order to balance the load and adapt against load variations. Oscillation of synchronization skews in the desirable range (-80, 80) ms and acceptable range (-160, 160) ms are observed. On the other hand, the reservation based synchronization has a high demand on the underlying resource management as it provides differentiation over network resources. The call establishment phase is complex, but once the QoS connections are established, the synchronization protocol is very simple. The only issue is to start the playback in a synchronized fashion and coordinate reservations between media types. The achieved performance is better and the skews are bounded in the range of (-10, 10) ms.

6. Conclusions and Future Scope

This paper proposes a framework for converting a multimedia presentation from its present day concept of displaying a set of fixed information to something which can be dynamically adjusted to suit the requirements of individual users. By representing the presentation as a set of meaningful objects, each associated with its own spatio-temporal parameters, it is possible to not only populate it with different content at different points in time by searching and selecting from a repository of media elements, but also to update the contents quickly and without much effort. It can also lead to an improved performance over low-bandwidth channels as objects which remain the same over subsequent frames need only be transmitted once, while other objects can be transmitted at different frequencies based on their variation patterns within the presentation. Another advantage of the scheme is its compatibility to new emerging standards. Object based compression schemes like MPEG-4[72] can be applied to compress each object in a presentation separately, the compression rate being a function of its importance in the presentation. This would reduce the overall bit-rate while preserving perceived quality. Standard description schemes like MPEG-7[73] can be applied to the CBR module. Moreover using a scripting representation like SMIL, presentations could be generated and redistributed using template based designs. Ready-made customized templates would help to cut down authoring time drastically. Schemes like MPEG-21[85] can be used to provide IPR protection through its Rights Expression Language and Rights Data Dictionary. The inclusion of a knowledge-base adds scalability to the architecture as it provides oppurtunities to incoporate new learning mechanisms and interpretation schemes, while the media repository makes it easy to add new media components. Moreover the seperation of the content from the layout means that each could be optimized independently for maximum efficiency. The paper also discusses each of the modules in the light of existing and on-going research activities to corroborate its feasibility of practical implementation.

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Presenting Indian Science and Technology Heritage in Science Centres

Part III

Shivaprasad M Khened

Introduction

Continuing from where we left off in the second part of the article, in this third and final part, areas that find a place in Our S&T Heritage gallery at National Science Centre, Delhi (NSCD), namely the technologies like Cannons, Coins, Glass, Art, Architecture, Music, Traditional Crafts, etc in which India has made profound contributions will be covered.

Cannons in India

India has a very rich heritage in the field of Cannons and that Cannons of varying sizes, shapes and material composition are found all across the Indian sub continent. India is perhaps one of the very few countries that can boast of a very rich presence of cannons. Not until long ago these treasures of India's past were not very well documented. Fortunately late Prof R Balasubramanium has carried out extensive research and made profound contributions on the rich collection of Cannons in India and his labour of love and extensive research has resulted in his publishing an internationally acclaimed book, The Saga of Indian Cannons, that has very rich illustrations supported with drawings and stunning photographs[1]. The choice of Cannons as a subject and for dedicating a section of the gallery at NSCD to this subject was largely based on the publication of a special thematically dedicated issue on this subject by INSA in its journal The Indian Journal of History of Science[2]. The display consisting of 3D models of different cannons, their engineering and fabrication details, material composition, dimensions and the technology of the cannons, were based largely on the findings made by Prof Balasubramanium and several of his coauthors in different articles of this special thematic issue and also in the paper Development of Cannon Technology in India[3] during the 16th to 18th Cent AD.

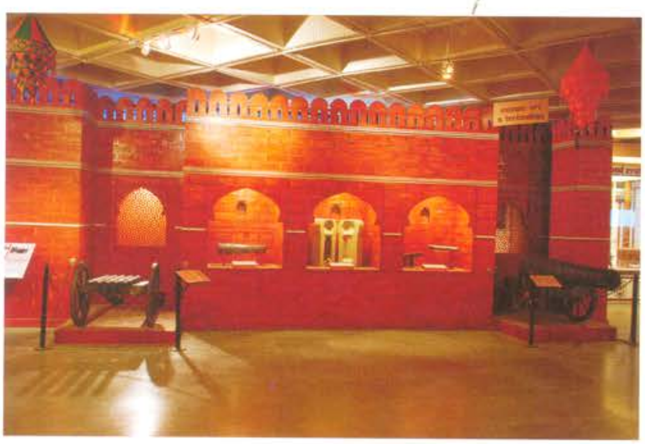

Fig. 1. Thematic display of the cannon section in "Our Science & Technology Heritage" gallery of NSC, Delhi.

This section of the gallery has a thematic display where a historic Moghul fort has been recreated in the exhibition space and this serves as a background to the display where cannons have been covered. This has been created in consideration of the fact that most of the cannons found across India are used mostly in the ramparts of the forts and *quilas*. In the foreground 3D models of some of the wonderfully crafted cannons of India have been displayed. Also on display are scaled down models of some of the cannons that depict the techniques that were used in making of these large sized forge welded cannons both of wrought iron and bronze. Cannon is any large tubular firearm designed to fire a heavy projectile over a considerable distance. Panchanan Neogi published the first catalogue of some of the wonderful forge welded iron cannons of India in his landmark 1914 book[4]. The use of cannons in warfare completely changed the complexion of the battles, an example of which can be seen from the first battle of Panipat fought in 1526 in which Babar won a stunning victory largely by using Cannon fire power skillfully. The high status of iron and steel technology in ancient and medieval India, which was covered in the previous issue of this journal, is amply reflected in the manufacture and use of forge welded massive wrought iron cannons of medieval India. These massive sized brilliantly forged and artistically crafted wrought iron cannons, since their introduction in Indian sub continent in the middle of fifteenth century right up to the pre-modern period, are scattered all over the country and their history, design, metallurgy, construction and technology have now been well researched and documented[1,2]. The 3D models of the cannons displayed in the gallery are based on the engineering drawings that show the actual dimensions and the manufacturing methodology used in forging these cannons, from the IJHS special thematic issue on Cannons.

The most notable cannons of India have been very richly illustrated in the gallery and also in the multimedia presentations that supplement the exhibition. These include the Rajagopala[5] cannon at Tanjore, the Dal Mardan – Forge Welded Iron Cannon at Bishnupur[6], the Forge Welded Iron Cannon at Bada Burj, Golconda[7], the Bhavani Shankar Forge – Welded Iron Cannon at Jhansi[8]. There are other notable iron-bronze cannons and bronze cannons located in different sites across India including the famous Mulik e Maidan at Bijapur, and Jhoola *thop* at Gulbarga which also find a place in the gallery. Design, construction methodology and other significant technical features of some of these spectacular cannons, researched and documented by scholars, primary among them Prof Bala, have been presented in the exhibition. Museums, monuments, forts and palaces in India have a very large collection of the cannons. The collections of cannons in possession of the Chennai Museum have been very well researched and documented[9]. A high level of engineering skill was involved in the construction of these cannons. Some insights on the possible method of manufacture have been interpreted from detailed study of their structural condition and Ultrasonic measurements carried out on the walls of the cannon which also provide insight into the different layers of rings and their dimensions and the type of fittings adopted in the manufacturing of these cannons.

Fathullah Shirazi

The gallery has on display three interesting 3D models of the cannon innovations made by Fathullah Shirazi[10]. The first model is a large sized working model of ingenious cannon cleaner – the *Yarghu*. Fathullah Shirazi, a versatile genius engineer, under Emperor Akbar's regime, designed and developed an ingenious machine for cleaning multiple barrels. This machine was called 'Yarghu'. Shirazi was born and brought up in Iran and he migrated to India on invitation from Sultan Ali Adil Shah of Bijapur. Emperor Akbar recognized his genius talent and invited him to join the Moghul Court at Agra. Fathullah Shirazi designed several utilitarian machines like the Portable Cannon, Multi-barrel Gun, Portable Floor Mill and Yarghu. The Yarghu machine could clean 16 gun barrels simultaneously thus providing an advantage for the invading army. The whole structure was constructed in an octagonal frame mostly made of angle iron. It consisted of toothed wheel with spokes with the hub fixed on the central vertical shaft. The machine could easily be detached and carried from one site to another on elephant back thus providing easy mobility to the machine. It consisted of eight bars; each bar was a composite structure made of a pinion and two brush-rods of equal length. The Cannons, which were required to be cleaned, were lifted up to the frame and placed in the 16 sockets provided in the frame. A bullock was used to rotate the whole machine. When the bullock rotated the axle at the base the wheel mounted on the top would start rotating. The teeth of the wheel, which had a gearing system of rack and pinion arrangement, provided the requisite motion. During the motion the brush-rods, meant for cleaning the cannons were set to motion with the movement of the pinion. The soft cleaning material mounted on each of the 8 shafts easily cleaned all the 16 cannons that were mounted on them as the machine was set to motion by the bullock[11]. Shirazi's ingenious method of translation of motion from linear to vertical with gearing mechanism of the pinion and the wheel in a single composite mechanical structure was a remarkable technological step in the 16th century technological know-how anywhere in the world.

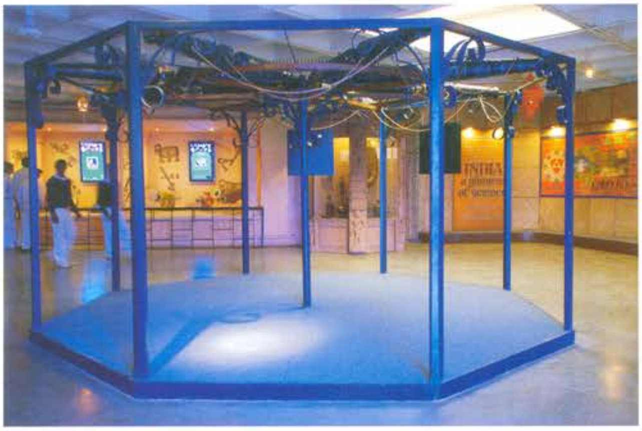
Fig. 2. Yarghu, the cannon cleaner.

Portable Cannon Machine

Shirazi also invented an interesting portable cannon device which made carrying artillery very easy. This machine was very light thus facilitating easy portability and providing advantage for the marching army. It had several parts, which could be screwed one into another and separated making it easy for portable transportation. The machine could be mounted ordinarily on a light carriage, and easily carried on to the top of a hill and rejoined for use. A greater advantage of it lay in its easy portability during post-haste expeditions. The emperor Akbar inducted many such machines into his army and extensively used these machines in very large numbers especially in places where transportation of very heavy artillery would prove to be a liability. A scaled down 3D model of a portable cannon device is displayed in the gallery.

Multi-barrel Gun

Shirazi also invented an ingenious Multi-barrel gun machine, a 3D model of which is placed in the gallery. This machine could serve the purpose of firing multiple artilleries with a single operation. All the barrels in this machine were cast or welded in a row so that they could be fired in quick succession by a single match-cord. The entire machine was transported from one site to the other using elephant drawn cart, which was used as its mount. This machine was especially useful for battering forts and breaking the concentrations of outnumbering enemy. In very quick succession multiple guns were fired from this machine, which acted like a modern day automatic machine gun. Induction of this machine proved to be a decisive advantage for Akbar in his innumerable conquests. Some authors argue that this machine could rightly be called the forerunner of modern machine-gun.

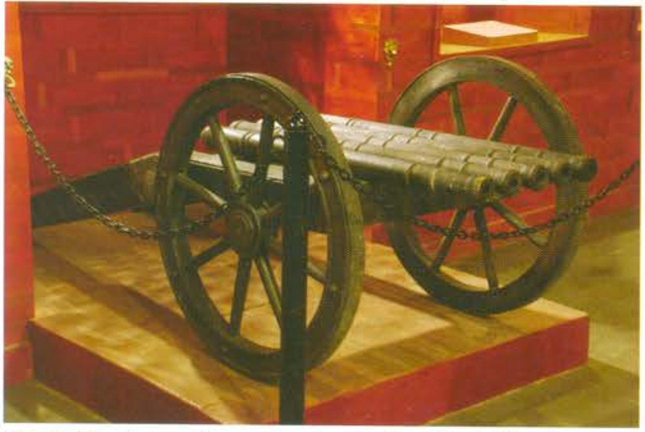

Fig. 3 . Multi-barrel gun invented by Fatullah Shirazi.

Coin Making

Of all the materials of antiquity coins are the smallest, yet, as a class are most authoritative in records and also are the widest in range. Thousands of specimens of coins have been found in India all across the country and this rich collection of coins have now been preserved in different museums and also in private collections[12]. Coins have symbolized an important aspect of India's History and Culture. To the ancient Indians a coin was not a piece of inanimate metal with an official stamp but a form pulsating with symbols, names of Kings, Gods, Goddesses, etc. Sources of our knowledge of minting coins in ancient India comes from the indication given by relevant coins, archaeological findings of different coins and other references in literature. The ancient Indian coins were mainly made of silver, copper, gold, lead, bronze, brass, etc. Historians have used coins of different periods as a source for reconstructing Indian history. This is particularly important for ancient and early medieval periods where written records are not available in adequate numbers. Coins corroborate evidence gathered from other sources, in addition to their helping in the reconstruction of major historical events. One such utility of the coins can be found in corroborating the period during which the famous Delhi Iron Pillar was forged and also the emperor who was responsible for forge welding this metallurgical wonder[13].

Among the Indian coins of antiquity the gold coins from the Gupta period have a special significance[14] and as such the exhibit on coin making has a miniature diorama presentation where the coin manufacturing scene of ancient times is depicted. The manufacturing methodology used in the coin making of the golden coins from the Gupta period and the exemplary artistic skills that show case sculptural finesse of the artisans involved in the manufacture of these coins using die striking method stand testimony to the fact that these coins are the works of art rather than the currency used for financial transactions[15].

From the studies of eminent scholars we are now in a position to understand the development of Indian coinage in different parts of the subcontinent under various dynasties through the centuries. Some of the eminent coins from ancient India include the Kusana coins, Gupta coins, Sangam age coins, Satavahana coins, Banavasi Kadamba coins, Chalukya coins, Rashtrakuta coins, Hoysala coins, Pallava coins, Chola coins, Pandya coins, Kakatiya coins, Sultanate coins, Moghul coins, Maratha coins, Sikh coins, Vijayanagara coins, Hyder & Tippu coins, East India Company coins and other foreign coins. The exhibition has on display some of the replicas of coins from ancient India.

A recreated coin-minting scene is also shown in the exhibit which reveals typical technological practices used in ancient Indian coin making. The main techniques of coin making in ancient India included the Droplet Technique, Punch Marked Technique, Casting Technique and Die Striking Techniques. The exhibit also has on display a mould used in the minting of the coins in the diorama. The mould for making multiple coins displayed in the model is reconstructed from the findings of the rare mould discovered by Dr Birbal Sahni. This ancient clay mould for casting of a coin was discovered by chance by Prof. Birbal Sahni at Rohtak in 1938[16]. This discovery later led to the discovery of many thousands of fragments of terracotta moulds, which were used for casting of coins[17]. The bronze coin, about 19 mm. in diameter, of the Yaudheya series, discovered at this site has been dated to about 100 B.C. From the very large amount of material available, Prof. Sahni has been able to work out in greatest detail the entire story of the casting technique employed in manufacturing these Yaudheya coins.